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China Report

SCIENCE AND TECHNOLOGY

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CHINA REPORT

SCIENCE AND TECHNOLOGY

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NATIONAL DEVELOPMENTS

SHANDONG ECONOMIC DEVELOPMENT AIDED BY DEFENSE INDUSTRY

Beijing KEJI RIBAO in Chinese 11 Jan 87 p 1

[Article: "National Defense Strengths Aid Shandong's Economic Development"]

[Text] The Shandong Office of Science, Technology, and Light Industry for National Defense is making contributions to the goal of promoting the province's economy by "enriching the people so that Shandong will prosper." It has been aided in this by the national defense industry departments in concluding contracts, agreements, and letters of intent of various kinds worth 49.55 million yuan in business.

The Jinning Antibiotics Plant imported extraction technology from the Ministry of Nuclear Industry's No 5 Research Institute to refurbish its (nai di mei su) extraction equipment and raised the extraction rate by 15 percent. This was a production increase of 875.5 kg and resulted in 660,000 yuan in benefits.

The Liayang Radio Plant brought in color TV chazhuanzi improved production technology from the Ministry of Astronautics, for an annual production of 200 stations, and realized profit taxes of 400,000 yuan.

Unceasing production brought new technology for stopping leaks in high-temperature, high-pressure situations. The Daybreak Machine Company of the Ministry of Aviation researched and produced this technology, which received the silver medal at the 13th Geneva International Invention and New technology Development Exhibition as well as the National S&T Progress 3d Class Award. The Zouxian Power Plant used this technology to stop a leak at the Laiwu Power Plant at 240°C and at 165 kg/cm pressure. This avoided an accident which would have shut down production.

With the assistance of the No 210 Institute of the former Ministry of Ordnance, Shandong in April 1985 established the first international on-line search terminal--the Shandong International Information Searching Center. This center utilizes modern communication methods and the world's three largest international on-line information search systems: the DIALOG and ORBIT systems from the United States, and Europe's ESA/IRS. Since going on-line, the center has conducted searches for more than 10 large academic institutions, more than

research units, and over 60 enterprises from the province's 12 localities and municipalities. These more than 250 searches on various topics have turned up more than 5,400 documents.

Shandong's practice of making full use of technology, qualified personnel, and superior equipment from the national defense industries has been a positive extension of national S&T defense results, with some resulting benefits. The province has invited national defense industry departments to come to Shandong to exchange information on new technology. Liu Ping [0491 5393], deputy director of the Chest Surgery Department at the Shandong Institute of Tumor Prevention and Treatment, has made use of the "L-G type lung cryogenic refrigerating regularization unit," which Liu himself created. This unit, when placed in a focal position in the patient, pours in liquid nitrogen to create conditions of ultralow temperatures. It has been successful in treating 41 lung patients. The unit has not only been used to freeze lungs during lung tumor surgery but has also been used in the surgical treatment of lung transplants and benign lung tumors.

Liu Ping and others wrote an article entitled "Clinical Studies of Frozen Lung Surgery," which was delivered at the First Asian-Pacific Regional Conference on Cryosurgery recently, and was warmly received by internationa. cryo-surgery specialists. The chairman of the International Cryo-surgery society, (Yutian Xingnan), stated that the unit's success was unmatched and had achieved new breakthroughs in frozen surgery.

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MINISTRY OF AVIATION INDUSTRY LEADS IN CIVILIAN GOODS

Beijing ZHONGGUO JIXIE BAO in Chinese 16 Jan 87 p 1

[Article by An Zhilun [1344 1807 0243] and Chang Yu [1603 2509]: "A Breakthrough for Aviation Industry; Last Year, Civilian Output Surpassed Military"]

[Text] China's aircraft industry is now becoming a part of the national economy's technological equipment. In 1986, the value of its civilian output surpassed that of its military output.

Reporters have now learned from the Ministry of Aviation Industry that last year, as part of a major change in the national economy and marketplace, the civilian output from the aviation industry system increased in value by 20 percent over 1985. Its proportion of the total output increased in the past year from 40 to 60 percent.

The design, production, marketing, and service of civilian aircraft have taken a new step forward. Last year, 15 Yun-7 aircraft were formally put into use in domestic air routes. The Yun-12 aircraft began to make inroads into the international market, with 10 of these exported to Sri Lanka.

There were greater successes generally in the development of consumer goods. Statistics show that, up to the end of last November, the Ministry of Aviation Industry had manufactured more than 2,800 automobile-type vehicles of all kinds, over 42,000 motorcycles, 4,600 automobile engines, over 34,000 motorcycle engines, over 80,000 bicycles, 30,000 washing machines of various models, 70,000 electric fans, 15,000 air conditioners, and 50,000 refrigerators, in addition to supplying more than 2,500 pieces of technical equipment to various agencies involved in the national economy.

In the many years that enterprises of aviation industry have been involved in the manufacture of vehicles, their equipment has become more advanced, and their technological strength solidified. Last year, 50 important new products passed technical evaluations at the ministerial and department levels. Included among these were such items as airflow spinning machines and loons, mine safety anti-explosive equipment, and water tank compressors, all of which were more advanced for China. In addition, development was begun on more than 100 new products.

The development of civilian products by the aviation industry is established on a firm technological and economic base. During the period of the Sixth 5-Year Plan, the ministry went through a technological transformation, setting up 60 modernized production lines. Forty-six of these are now listed among the national leading group of technologically transformed production lines which have shown great progress. Last year 3 of these lines were checked out and accepted ahead of schedule, another 15 may be this year, and the remainder will for the most part be checked and accepted in 1988.

According to the ministry, the aviation industry's production of civilian goods in 1987 will continue its constant development of China's civil aviation. At the same time it will provide advanced technological equipment for those departments concerned with communications and transportation, energy, and the national economy. In the future, the Ministry of Aviation will be a consultant for the enterprises involved in textile manufacturing, light industry, commerce, medicine and health, etc. as well as the economic management departments of the various provinces and municipalities. There are plans to move forward in developing interactive economic cooperation during the Seventh 5-Year Plan period in order to build and serve the national economy.

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TONGJI UNIVERSITY SUCCESSFUL WITH FOREIGN ENTERPRISE CONTACTS

Shanghai WENHUI BAO in Chinese 21 Jan 87 p 1

[Article by Ding Runling [0002 3387 0109] and Zhang Chengdiao [4545 2052 6860]: "Tongji Breaks Free of Doing Only Intercollegiate Contacts; Doing Joint Research with Foreign Enterprises and Organizations; Improving Teaching and Research Conditions While Strengthening Exchanges with International Academic and Business Communities"]

[Text] Tongji University has opened up foreign contacts and new channels for cooperation. In addition to its intercollegiate contacts, Tongji has established cooperative relationships with more than 150 foreign enterprises, economic organizations, and foundations. They are pooling their resources internationally to operate the school, develop bilateral joint-research projects, and further the trend to internationalizing higher education.

There is a trend in joint-research projects away from unilateral intercollegiate contacts toward bilateral arrangements with international enterprises. For example, this school and a French gas company jointly developed a new model combustion technology for the 1980s, carrying out "Shanghai gas reciprocal joint research," from which our side acquired China's first "gas reciprocity map." Tongji University carried out "industrial district research" and "research on the application of computers in municipal planning" with, respectively, the Osaka Tsumizu Housing Company of Japan and the Siemens Co. in the Federal Republic of Germany (FRG). Both of these research projects were within the international scope of "plant (industrial)-school relationships." Some of the university's cooperative projects with the foreign industrial community have become a part of Sino-German and Sino-U.S. joint technical agreements.

Funds provided by the foreign business community to carry out research and to train manpower have for the first time become the majority of higher education funds raised from abroad. At present, more than half of the year's scholarship quota at Tongji came from abroad, and of this amount, over half was furnished by the foreign business community. In the FRG alone, more than 150 enterprises have organized a "Friends of Tongji University" association, which has provided over 40 scholarships for advanced study. The university and the FRG jointly concluded a "China road design" research problem, and

with a subsidy from the Volkswagen Automobile Company Foundation, research personnel were able to purchase laboratory equipment and make a field trip to the plant.

Cooperation with the foreign business community and with foreign economic organizations has aided in improving Tongji's teaching and research conditions and has mediated its channels of communication with the internationa scholarly and business communities. As an example, the (Fei si tuo) Company in the FRG furnished over the past year more than DM10 million. This made possible the acquisition of a complete set of equipment, valued at DM300,000, for the "Contemporary Control Technology Training Center," which is jointly managed by the university and the company. The (Ke si te) Chemical Company in the FRG also provided two exhibit booths at the national large-scale Chemical Engineering Progress Exhibition held in Frankfurt. These were especially for Tongji University, as a means of introducing the current state of teaching and research at the university. Establishing contact with foreign businesses has also advanced Tongji's contacts with other academic institutions: in the FRG alone more than 10 universities have asked to set up relationships with Tongji.

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CAS INSTITUTES' STAFF WORKING WITH TECHNICAL BUSINESSES

Beijing KEJI RIBAO in Chinese 22 Jan 87 p 1

[Article by Wu Ming [0702 2494] and Meng Xiangjie [1322 4382 2638]: "In Order To Reorganize the Traditional Research Model and Gain Greater Societal Benefits, CAS Formulates a New Structure; 'Many Kinds of Soldiers Fighting'"]

[Text] There is a "fission" going on right now in the Chinese Academy of Sciences (CAS). A large group of research institutes has set up a technological property entity, and an increasing number of S&T personnel are leaving the "cold bench" of work in technological development or the popularization of results. These personnel are formulating a new setup of "many kinds of soldiers fighting in coordination."

Statistics show that the CAS has now established more than 80 technological companies of various types, and these have more than 1,000 S&T personnel in high- and medium-level technical professions who are applying themselves to technological-development and management activities.

CAS, with its more than 80,000 staff members, is China's total center for natural science research. Dur to the research institutes' independence from the economic system, for many years now research results have emerged in large numbers, yet many of these results have been turned into "junk" stored away in a safe. The traditional research model and traditional value judgments have helped cause a situation of "stressing fundamentals and belittling applications" and "stressing results while belittling development," thereby severing the tie which turns results into production.

People have imaginatively described the changes taking place in CAS as "looking outwardly like an egg but really making a quality change." Within the research institutes, the initial change took place in the value judgments of research staff, with the S&T staff's values being reflected not only in their scholarly articles and product samples but also in their setting criteria for the size of their contributions to society. They began to extend their vision to the needs of society in carrying out their research projects. At the same time, change was taking place in the organization of groups within the research institutes, from which emerged a new work force concerned specifically with the work of popularizing and developing technological achievements.

In the area around the research institutes in Beijing's Zhongguan Village, a sizable group of technical businesses has sprung up like bamboo shoots after a spring rain. It has become an established theme for S&T personnel to come out of the institutes and into the businesses. Zhongguan Village today, with its modern research building and numerous businesses, stands out in sharp contrast to the past. Advanced technology is going from the laboratory into the companies' technical offices. The new look is bringing out even newer technology. More than 70 research staff members of the Acoustics Institute have come out of the laboratory and established a high-technology labor force which is concerned with the development, manufacture, and marketing of high-technology products. The new projects undertaken in the past year totaled 20 million yuan. The staff of the Automation Institute established an automation technology institute in 1984, which aimed at extending the institute's technological achievements to society. At the same time, these staff members have taken charge of new projects from society, returning to the laboratory to do experiments. At present there are more than 100 research personnel participating in the companies' new-product development work.

CAS today is opening wide a large door, doing its utmost for society and for the world. While maintaining a high level of excellence in research, it is stressing the societal benefits and economic benefits of its results.

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NATIONAL DEVELOPMENTS

PATENT OFFICE DIRECTOR DISCUSSES PATENT PROCESS

Tianjin JISHU SHICHANG BAO in Chinese 17 Jan 87 pp 1, 3

[Article by Wang Yaxuan [3769 0068 6513]: "How Patent Technology Enters the Marketplace: A Meaningful Forum"]

[Text] Editor's note: Zhejiang University is a famous seat of learning in China, rich in S&T strength, stable and unified in its governance. Many of its faculty members and students concentrate on scientific research and teaching with remarkable success. Over the past several years, this institution has won 16 national prizes for inventions, more than 300 departmental and provincial-level awards for S&T accomplishments, and 7 progress awards. There have been 105 patent applications from the university, of which 15 have been 105 patent applications from the university, of which 15 have been approved. Zhejiang is in second place among China's institutions of higher education in number of patent applications (Qinghua University is first).

During the past year, Huang Kunyi [7806 0981 4135], head of the Chinese Patent Office, held a discussion with Zhejiang University's patent attorney and some of the school's inventors. At this meeting, he answered some questions they raised concerning patents entering the technological marketplace. His responses were very meaningful in their guidance, and excerpts are published below.

Chen Guoping [7115 0748 1627] (Research Office deputy director): S&T results are not too valuable right now, so people are unwilling to spend money to buy them.

Director Huang: How should we look at this question of whether or not they are valuable? I believe that if something can be linked with economic development then it is valuable. What is a high-level invention and what is a low-level invention? If you have completed some key project, or tackled some key problem, then I call that high-level technology. Is it just a matter of whether inventions are valuable? I feel that so long as there is technology which can be obtained from a patent which breaks with convention, although the technology itself may not be of a high level, still, if it leads to major economic benefits, then it is of a high level and so of a high value. The East China Chemical Engineering College does not have many projects, in fact it is responsible for only three, but all of them carry very great economic

benefits. One of these is an inexpensive secondary catalytic agent which can be useful for purification when used in automobile exhaust combustion, replacing the expensive secondary catalytic agent currently on the international marketplace. It is of good quality and low in cost, so it is very strongly competitive. There have been more than 700,000 orders placed for this product abroad, worth more than $7 million. Another project is a new technology for the preparation of citric acid. The university is now negotiating with several foreign nations for transferring this technology, which also may have considerable economic benefits. Yet another project is in fermentation catalysis technology, which led to the resurrection of a plant in Taixing, Jiangsu. After this plant had begun using the technology gained from this project, the quality and transfer rate of its product rose noticeably. Its product exports totaled more than $1 million this year and netted more than 9 million yuan in profits. So I would say that from a patent standpoint, the question is a major one in resolving the present economy.

A Hunan inventor studied a bamboo board for assembling flowers and applied to the China Patent Office for a patent on the plan he had followed. Not long ago, the board he designed was laid out in a room at the Patent Technology Exhibtion. Li Peng [2621 7720], Song Jian [1345 0256], and many of their colleagues from various provinces and municipalities all viewed it, and everyone regarded it as a very good resource for decorating a room. The resources for it are abundant, it is simple to produce, and its use is widespread; it is good and cheap. Naturally, this is not like the old model board, so that there has been a series of technical problems in the processes of putting the bamboo through machining and chemical treatment and then in its installation. At present, Hunan has organized a joint development task force, which will include such matters as the processes of machining, installation, and foreign exports. They are also drawing upon the participation of the Academy of Forestry Sciences. Even relying on the technical advice of these academics and professionals, it is possible that no one will see the solution, but it is possible that a way will be found for the mountainous and impoverished regions of the south to make use of bamboo.

Chen Guoping: How do you view the relationship between awards and patents?

Director Huang: People think of an award as a kind of honor, and that is of course correct. What is the distinction between an award and a patent? For example, the award certificate is hung on the wall, while the patent is filed in a cabinet. This is because the former is an honor, and the latter is a legal document, a document which verifies property, and if anyone infringes on this right, it can be the basis for a lawsuit. This is the real distinction. The patent also implies encouragement, as an honor does. All patent documents are now being translated into English, and recorded in the patent document is the name of the inventor and the name of the person making the patent application. This is then stored in a global database. If someone at Zhejiang University invents something, this global database can be searched to see if a previous patent certificate has been awarded. It is true that the patent application is somewhat troublesome, and one must go through a complicated

examination process, and even then there may be no response. But if the patent process is not done well, and the patent is geared to the entire world, someone doing the same thing poorly still could beat you in court.

Jiang Jingping [5592 7234 0988] (professor and head of the Research Section): How should patent technology be implemented?

Director Huang: In the university, it is the implementation problem which must be resolved.

There are basically three aspects to technology implementation: first is the technology aspect; second, the production aspect; and third, the marketplace aspect. We have neglected the marketplace in the past, but from now on it will have a significant role. If no one wants the technology, then it is pointless to talk of implementing it.

Whenever the university is entrusted with some research, it should be made clear right from the time they draw up the contract how patent rights will be handled when there is a patent application. The patent laws and applications stipulate that patent rights belong to the unit completing the invention, but they also state that there are other agreements which can be exceptions. Therefore, if the contract is unclear, it is easy for a dispute to arise when the patent is applied for. It is very difficult to transfer an item of technology: it creates a lot of work, and in addition to the technical problems, there can be economic and legal problems as well. It would be a most undesirable situation if we had, within a short period of time, a professor doing research and teaching, while simultaneously discussing a contract and then having to take legal action. There must be people whose business it is to handle the problems of technology development and resultant disputes. The patent attorneys at your university all were selected because they are better at mediation work. This is a new type of manpower, people who understand technology as well as the law and economics. This sort of talent should be encouraged, so they will be contented in their work.

A patent is really just a technological plan, or just the results of a new experiment. Therefore, the first time it is carried out, it is really an industrialization experiment. It is essential that enterprises be assisted in developing it. How much technical personnel take in or spend must be fixed according to the amount of technical direction work involved and how much material is supplied. But it may turn out in the end that there is little income, for this is high-risk investment. If it is not practical and realistic, or if the price is set too high, or the production unit cannot get it out, then later on it will have to be deleted from the product inventory.

It is the same in selling technology: you can only derive an output value of 5 to 10 percent. In applying for a foreign patent while it is important to make consumer products for export the major objective, we should first implement it domestically to the best of our ability.

Jiang Jingping: The patent contains in it the technological tricks of the trade; some professors worry that if the examination doesn't go through, the technology will be leaked out.

Director Huang: There is a problem with unsanctioned disclosures. If the search uncovers something similar which already contains your technology, then your application will not go through. Seeking protection for technology is tantamount to making it public, and at present the majority of clauses in the law deal with problems in the area of dissimilarities. If it is not easy to make some part public, then you cannot seek protection for it. We do not sanction everything being made public, but if protection is sought for one part, then it will be stated on the patent application document that that part is extended protection, so that what is called "know-how" will not be public technology. Then, when it is transferred, it will be stated clearly in the contract that this cannot be divulged to a third party. If it is obtained by someone else, one can only investigate the other party to the contract and can only secure weak protection in the law. Our patent law is not like this: in our law, one can sue the third party, and whoever in China uses your technology can be sued by you. But if you do not make application, and someone else does the same technology, and he applies for a patent, then there is the chance you could lose any possibility of getting patent rights.

It is my opinion that under socialism the patent system very possibly surpasses that of the capitalist nations. The patent systems of the capitalist nations were not conscientiously formulated; rather, they evolved over several hundred years. Inventions and creations are made by laboring people as well as professors, engineers, workers, students, etc. Under socialism, our accomplishments in extending legal protections to laboring people ought to maximize their usefulness.

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DEVELOPMENT OF CHINA'S GAS TURBINES CHRONICLED

Beijing HANGKONG ZHISHI [AEROSPACE KNOWLEDGE MAGAZINE] in Chinese No 2, Feb 87 pp 14-15

[Article by Tang Ding [2768 0002]]

[Text] Gas turbine is a highly efficient, advanced, and energy-conserving power plant. Since the 1950's, gas turbines have been used not only in aviation but also in other areas such as petroleum, electric power, motor vehicles and ships. Aviation gas turbines are considered the most advanced; their special features include: 1) high thermal efficiency, which results in fuel savings; 2) ability to use different types of fuel; 3) small in size, light weight, and easy to operate; 4) long life and high reliability; 5) low investment, high pay-off.

In the past, aviation gas turbines were primarily designed for military use. In recent years, under the guideline of military-civilian cooperation, gas turbines are increasingly being used on the ground, and efforts have been initiated to develop non-aviation gas turbines. After many years of dedicated hard work, breakthroughs in new technologies have been achieved, and applications in the non-aviation areas are expanding. A team of technical personnel devoted to gas turbine development has been formed and is constantly growing stronger. However, there also exist some major problems whose solution requires serious study and immediate attention.

Development of China's Light Gas Turbines

Since 1976, the Ministry of Aviation Industry has developed 5 different types and 11 different models of modified aviation gas turbines. Three different types and four different models are already in production; a total of 65 modified turbo-prop (TP) and turbo-shaft (TS) engines have been produced; they are used for oil field power generation, water injection, energy conservation, heat supply, fire extinguishing in coal mines, air-cushion boats, and for powering railroad cars. The year 1985 deserves special mention because significant achievements were made during that year, as summarized below.

A Combined System for Generating Heat and Electricity in Operation for the First Time. In 1985, the Li Ming Co. of Shenyang successfully developed the

TJ-6G gas turbine which uses natural gas as fuel for generating heat and electricity; it was later put into service at the Da Qing oil field. By January 1986, it had accumulated 8,917 hours of operation, generated 34.76 million kilowatt-hours of electricity, and produced 90,531 tons of steam. The operating efficiency is maintained at above 91 percent. At the product certification conference sponsored jointly by the Ministry of Aviation Industry and the Ministry of Petroleum Industry, it was agreed that this type of combined heat and electricity generator units are superior in terms of structural simplicity, operational reliability, and ease of maintenance. It is capable of not only conserving energy resources and increasing steam production, but also providing residential hot water; the total benefits on both the supply side and the demand side are estimated to be 4,003 yuan per year. After installing two generator units and two water pump units, the Da Qing oil field has signed a further agreement with the Li Ming Co. to purchase four such units; the Zhongyuan oil field has also signed an agreement to install new generator units.

Water Injection in Oil Fields. On the basis of the TS-6G design, the Jiangxi No 370 Factory developed an industrial gas turbine which uses natural gas as fuel. In April 1985, they began water injection tests at the Zhongyuan oil field; by the end of that year, they had accumulated 2,400 hours of operation, and the total amount of water injected exceeded 170,000 cubic meters. Based on an estimated saving of 10 kWh of electricity for each cubic meter of high-pressure water injected, the annual saving of electric power per generator unit is approximately 8 million kWh.

Use of Inert Gas Fire Extinguishers in Mine Pits. In a joint effort between the No 608 Bureau of the Ministry of Aviation Industry and the Wushun Coal Research Institute, the DQ-1000 inert gas fire extinguisher was successfully developed. It is based on the principle that by burning the exhaust gas from the TS-5 gas generator in the newly developed auxiliary combustion chamber, the oxygen content is reduced to less than 3 percent, and an inert gas is produced which can suppress combustion. The gas is then water-cooled to a temperature below 90°C and sprayed into the fire zone; by isolating the open fire from fresh air and sealing the fire zone, the fire can be readily extinguished. A positive evaluation of this unit was reached by the inspection committee organized jointly by the Ministry of Aviation Industry, the Ministry of Coal Industry, and the Coal Research Institute. On 27 December 1984, the unit was transferred to the Qingshan coal mine of the Pingxiang Bureau of Mines for underground simulation tests; the test results showed that this unit was stable in performance, met the fire extinguishing requirements, and was suitable for underground use.

New Breakthroughs in Burning Heavy Oil. The Nan Fang Power Machinery Co. has made new breakthroughs in testing a TP-6 gas turbine with a modified heavy-oil combustion chamber. Tests show that by using No 60 heavy oil in place of the No 20 mixed heavy oil, combustion actually improves in spite of the degradation in oil quality. Currently, the TP-6 heavy oil combustion experiment is proceeding at full speed; the plan is that by the first quarter of 1987, an integrated unit will be developed for further testing.

As a result of the work done during previous years, significant progress was made in several major areas last year. These included the following: modifying the WJ-6G2 into a power plant for air-cushioned landing craft; using the WS9G1 6,000-hp gas turbine for power generation; and developing the WS9G2 13,000-hp ship-borne gas turbine.

Expanding the Range of Application of Gas Turbine in China

To apply the mature technology of aviation gas turbine to the areas of transportation and energy exploration is an urgent problem facing us today. To achieve this goal we should take the following steps:

We should designate the work of developing modified aviation gas turbines as part of the national economic development plan, and allocate the necessary funds. Currently, due to the lack of a clearly defined leadership relation, there is no identified source of funds. The Ministry of Aviation Industry is forced to explore different means to raise funds, but it is difficult to satisfy the enormous needs of gas turbine development. If this situation is allowed to continue, China's development program will undoubtedly be affected, and foreign gas turbines will eventually take over the Chinese market. Therefore, we suggest that the national economic commission assume direct responsibility for the gas turbine development work, and for solving all the related problems. This will benefit both the military and the general public.

As in the case of civilian aircraft, the state should establish a policy to protect the gas turbine industry. In recent years, many organizations have imported gas turbines from other countries. According to preliminary statistics, between 1983 and 1985, China had purchased 22 gas turbines in 6 different models of the 10,000-kW class. On the one hand, importing these machines will benefit China's development and production; on the other hand, large number of imports will adversely affect or even suppress the domestic gas turbine industry. Furthermore, because of the lack of import control and a unified import policy, the importing organizations are completely uncoordinated. As a result, not only do we suffer economic losses from imports, but the variety of imported models will lead to problems in maintenance, repair and supply of spare parts. A comparative study has shown that domestic gas turbines produce higher economic benefits than imported units because the amount of investment and operating costs are lower, and significant amount of foreign exchange can be saved. For this reason, we suggest that as a measure to protect the growth of China's gas turbine industry, in the future we refrain from purchasing the gas turbine models which are being manufactured domestically. Also, the Ministry of Aviation Industry should be given authority to manage and control the importation of all gas turbine technologies and products from abroad.

We should also promote international and domestic cooperation, and establish lateral economic connections. In 1985, at an international gas turbine exhibit organized by this ministry, 34 different manufacturers from the United States, Great Britain, and France displayed a variety of different products. Such exhibits promote technical exchange and international friendship, hence we should continue to expand international contacts and encourage

international cooperation. There is currently a joint effort between the Ministry of Aviation Industry and a U.S. manufacturer to develop the FT8 30,000-hp gas turbine; we should use this as basis to develop a complete product line ranging from 600 hp to 30,000 hp. At the same time, we should also promote international cooperation in developing unit-level products such as regenerators and compressors for a regulating system, in order to enhance the competitiveness of domestic products.

We must also establish lateral connections within China and promote internal cooperation. Currently, there are 10 gas turbine production plants and 7 design institutes; 90 percent of the production capabilities are under the control of the Ministry of Aviation Industry, the remaining 10 percent are distributed among the Ministry of Machine Building, the Ship Building Co., and the Academy of Sciences. These technical resources including personnel and technical facilities should be united so that the potentials of individuals can be fully utilized to achieve breakthroughs in key technical problem areas. Also, funds should be properly allocated to accelerate the manufacturing of gas turbines in order to satisfy the needs of the petroleum, chemical, coal railroad and ship building industries, thus making further contributions to the national economy.

The State Planning Commission and the State Economic Commission have already approved a "Light Gas Turbine Development Center" to be established by the Ministry of Aviation Industry. But an intelligent decision on how to organize such a center is urgently needed so it can begin operation and provide its service to the industry as soon as possible.

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ROLE OF CAD IN NATION'S MMT INDUSTRY EXPLORED

Dalian ZUHE JIQUAN YU ZIDONGHUA JIAGONG JISHU [MODULAR MACHINE TOOL AND AUTOMATIC MANUFACTURING TECHNIQUES] in Chinese No 11, Nov 86, pp 2-7

[Article by Dong Yili [5516 0001 0500] and Jiang Meiran [5592 5019 3544], Dalian Modular Machine Tool Institute: "Views on Development of Computer Aided Design (CAD) Research in China's MMT Industry"]

[Excerpt] I. Developing CAD Technology Applications Research Is An Urgent Mission for China's MMT

A modular machine tool (MMT) is a machine tool with a very high level of the three "-izations" (standardization, generalization, and serialization.) Because of its high degree of efficiency and stability in industrial processing precision it does not need to be operated by a worker with a high level of technological training and thus MMTs are widely used by machine manufacturing departments engaged in large batch production and have earned extremely large socio-economic benefits. In recent years, while further improving the precision, reliability, and overall automation of MMT to suit the needs of upgrading machine products, increasing the number of models, and engaging in medium and small scale batch production, we have also been developing in the direction of flexibility, and a number of flexible MMT have appeared--flexible industrial processing modules, flexible industrial processing lines and systems--which have greatly expanded the applications realm of MMT. Because of the important role of MMT in the machine manufacturing industry and the special features of good foundation of the three "izations", relative maturing in design methods, and the high frequency of design of MMT, MMT CAD has been taken very seriously abroad. In the early sixties, the United States, USSR, and Japan began research in MMT CAD. Currently, not only to the industrially developed countries generally use CAD technology for some hydraulic, electric control systems and mechanical parts for MMT, but the development of MMTs and MMT automatic line proposals are carried out using CAD. Some MMT components, such as multiple spindle boxes have been formed better CAD/CAM systems. And although some work has been done in China in recent years on MMT CAD, and we have achieved a batch of results of a definitely high level and trained a group of scientific researchers, yet due to a variety of factors, these results have not yet been put into use

completely or at all. Currently, MMT design is still carried out manually one machine at a time.

Because design techniques are backward, there is a rather large gap with the industrially advanced countries of the world in China's current MMT design, whether in terms of design speed or in terms of design quality.

In terms of speed of design, the industrially developed countries the time required for a complex automatic line from order to delivery is about a year, of which the design period is only three or four months. For example, the four automatic lines provided to the Shanghai Camera Plant by Japan took only 8 to 10 months from negotiations to delivery. Yet in China, an automatic line of similar complexity requires over half a year for just the design alone. That is, the design of a single ordinary MMT unit frequently requires 3 or 4 months for completion. Thus, since the design and manufacture period for an MMT and its automation system in China is excessively long, we are frequently unable to satisfy the demand for MMT user plant product upgrading and competition. In recent years, it has often occurred that the MMT industry has been unable to accept a job because the design and manufacture time demanded by the customer has been very short. This has had an impact on China's MMT and even the development of the entire machine building industry.

In terms of design quality, in the past few years, although with the spread of computer technology, computers have been used for finite element analysis and improvement design methods of some MMT parts (such as basic components and axles), most design is still "experience design." Thus, the scientific basis of design has been inadequate and design quality has been low. In addition, it has been difficulty to avoid many man-made statistical and written errors, thus causing unnecessary economic losses. These have had an impact on the success rate of an MMT and to a certain degree has also affected the design and manufacturing cycle.

It should be pointed out that during the Seventh 5-Year Plan, China's machinery building industry, especially industries engaged in large batch production of automobiles and tractors, are facing the task of product upgrading and enterprise innovation. And these industries are also the primary customers for MMTs and MMT automatic lines. The quantity of MMTs and MMT automatic lines they need is very large. On the basis of the above situation, and taking into account the development of the machine building industry as a whole, according to the 1985 MMT Industry Conference estimates, during the Seventh 5-Year Plan, the national need for MMT will be approximately 13,500 units [1], or an average of 2,700 units per year. But currently, although 31 units in China's machine-building industry are engaged in MMT design and there are nearly 1,000 designers, because of the backwardness of the design techniques, and the volume of design annually, even including design work done by the customer himself, can only amount to 600-1,000 units which is far from satisfying the demand of the machine building industry on the MMT industry. In addition, it should also be noted that the mainstay forces among the MMT designers are all middle-aged scientists and technicians. Although they have an abundance of experience, for the most part they no longer feel energetic. And, a great deal of the work in traditional manual design involves drafting, statistics, and tabulation. According to

statistics, over 50 percent of the work in designing is drafting and the really creative labor time is less than 20 percent, thus it is clear to see that the current manual design methods are no longer favorable for taking advantage of the intelligence and experience of China's MMT design personnel so that they can be better involved in creative design labor. In particular, considering that the dramatic increase in the demand for MMT in the Seventh 5-Year Plan and after but that in a short period of time it will also be difficult to rapidly expand and increase the ranks of designers, especially experienced designers. Thus it could be said that developing in a planned way CAD research and applications in China's MMT industry is no longer only a long range technological development policy, but an urgent task now.

In its Report on the Development Strategy for China's Electronics and Information Industry, relayed by the state Council it says: "We should select one or two industries and in a planned and systematic way use electronic and information technology to carry out the technological reform of the entire industry and accumulate some systematic experience." With the approval of Deputy Premier Li Peng, the Electronics Industry Invigoration Leading Group of the State Council has selected the MMT industry as a test reform industry for using electronic and information technology. The application of CAD technology in design of MMT and its automatic lines as one of the important machine tool products very clearly is an important part of the overall mission to use electronic and information technology to reform the machine tool industry.

II. The Situation and Development Trends in MMT CAD in China and Abroad

2. The Developmental Situation in China

Knowledge of the application of CAD technology in MMT design was also rather early in China. In the early seventies, in cooperation with the Nanjing Wired Radio Plant, the Dalian MMT Institute developed a special machine for MMT multiple spindle box, coordinate calculations. In 1973, Fudan University developed a multiple spindle box coordinate calculation program [24]. Subsequently, Shanghai Jiatong University, Xian Jiaotong University, Guizhou Engineering College, and Dalian Engineering College wrote main spindle box [0031 6519 4630] coordinate calculation programs [25.26.27.28] which resolved the problem of multiple spindle box coordinate calculations. On this foundation, Shanghai Jiaotong University, Shanghai Municipal Mechanical and Electrical Design Institute, and Fudan University also carried out some explorations with regard to automation design of MMT multiple spindle boxes [29]. However, because of limitations of domestic computer technology and applications conditions, research on MMT CAD technology has not been able to develop further.

China's more comprehensive research on MMT CAD formally began at the end of 1978, when the topic of drilling MMT CAD research, which was made a key project by the Ministry of Machine Building Industry and was made the responsibility of Shanghai Jiaotong University, Dalian MMT Institute, and the Ministry of Machine Building's Institute of Automation with the participation of Dalian Engineering College, Qinghua University, Beijing Industrial University, Shanghai Machine and Electrical Products Institute and the Dalian

Machine Tool Plant and the Third Design Institute of the Primary Agricultural Machine Ministry which formed a topic group to carry out the work. The topic included three major parts:

(1) Multiple Spindle Box CAD system: including
multiple Spindle box transmission system CAD;
multiple spindle box transmission parts checking system;
light pen graphic display technology application;
multiple spindle box CAD database;
multiple spindle box automatic drafting.

(2) MMT hydraulic transmission system CAD.

(3) MMT electrical control system CAD.

The entire project took 4 years at an estimated cost of nearly 100 man-years, and the three universities had it passed formally through ministry level appraisals in 1982 and 1983 and won two ministry development prizes.

In addition to the above topics, in recent years many units have also applied finite element method to analytical calculations for such MMT parts as slides [30.31], revolving tables [32], and axles [33.34]. The Dalian MMT Institute also conducted design improvement research on MMT rigid bored main shafts [55]. This project won three Ministry of Machine Building prizes at the Computer-Aided Design Engineering Exchange Conference held by West Berlin University, Shanghai Jiaotong University and the Dalian MMT Institute in 1984.

In addition, many units have developed a large number of applications programs on microcomputers related to shaft, gear, and end milling cutter parameters as well as MMT industrial processing and cutter calculations. Some institutions of higher learning have also done some useful explorations in design improvement of MMT multiple spindle box transmission systems.

In short, a great deal of work has been done in recent years on MMT CAD and some results have been achieved which have reduced the gap with foreign levels, accumulated experience and training a corps of researchers.

However, it should be noted that there is still a rather large gap when compared with advanced foreign levels. For example, very little work has been done yet on such basic research as man-machine interactive image design methods, automatic plotting methods and various types of image libraries and various types of MMT CAD algorithm libraries and databases. A great deal of applications software still must be developed in such areas as MMT and automatic line formulation, supports such as beds and chassis and the design of cutters, tools, and jigs. Some applications software which has already been developed must be applied as quickly as possible and further improved. Thus, only by further developing MMT CAD research and applications in an organized and planned way can we catch up with the advanced countries and achieve advanced world levels in a very short time.

III. Some Views on Developing CAD Research in the MMT Industry

As was mentioned above, although China's MMT industry has carried out some developmental research work in the CAD area in the past few years, and made some accomplishments, generally speaking we are still in the preliminary stages and not progressing very fast. The main problem is the lack of overall planning and that forces inside and outside the industry have not been organized thus CAD work is in a spontaneous state, most of the limited manpower is engaged in similar types of work (such as multiple spindle box coordinate planning, etc.) creating low level duplication; some have computers but they are complex and have not yet been matched with the necessary software and basic support software so that it is very difficult to advance work.

We feel that to rapidly and effectively develop research and applications work on China's MMT CAD we should pay attention to problems in the following areas:

In guiding thinking and organization we should:

1. Develop research and applications in a planned and measured way from specific to general.

Developmental research on CAD technology requires a substantial investment and manpower. Currently, China does not yet have for sale a CAD system which bundles hardware and software, but the CAD systems imported from abroad generally cost several hundred thousand dollars. Even microcomputer CAD systems generally cost more than $100,000. On the other hand, CAD technology is complex, secondary development of support software and applications software development require considerable manpower but most of China's MMT industry design and applications units today would have difficulty providing such economic resources and software development forces, thus determining that China's MMT CAD development research work can only be carried out by individual units with the right conditions and then gradually be applied broadly within the industry. To, only in this way can we avoid reckless purchases of equipment and software and secondary development and applications research work not catching up with a long period when it cannot be used and a considerable waste of manpower and materiel in a rather large number of personnel wasted in carrying out duplicate labor.

2. Establish a unified model as quickly as possible centered on medium and small scale CAD systems.

Currently, the units in China engaged in MMT design, except for large plants such as the First and Second Automobile Plants which can think of starting from the overall position of factory computer applications and use large-scale CAD systems, most units should consider establishing medium-scale CAD systems based on super-minicomputers such as the VAX-11 series or small-scale CAD systems based on mini- or super-minicomputers. Small-scale CAD systems in particular are low in cost and suited to use by enterprises for developing CAD work.

In terms of selecting a computer, we feel that related MMT industry units should be as uniform as possible. There is a great deal of work involved in

setting up an MMT CAD system. Due to differences in language, norms, and standards, almost all imported support software requires secondary development focused on China's situation and graphics work stations, plotters and printers all have to have Chinese character input and output functions added to them. In terms of applications software development, we also need to establish large special databases and graphics libraries. This work requires the investment of a large amount of manpower and cannot be carried out by each unit. Thus, in purchasing computers and CAD support systems, units within the industry should be as uniform as possible in their selections in order to facilitate organizing common development, mutual exchange and accelerate the rate of development.

3. Basic support software should be primarily imported, but applications software should be primarily developed in China.

From the perspective of the present situation, the ability of the domestic MMT industry and even the entire machine tool industry to develop a complete CAD support software system is inadequate. Even if the primary software modules are imported, it will take a long time to develop the interfaces and improve and expand it into a complete entity. In addition, current CAD hardware equipment relies on imports thus developing support software systems should be matched with hardware and adjusting hardware interfaces is difficult. Thus, we feel that if we purchase CAD systems they must be complete or at least should match such basic support systems as imported high level language editing systems and database management systems, and interactive graphics software.

As regards applications software, since the general purpose portions and MMT standards of various foreign countries are different, thus, directly using the possibilities of imported foreign MMT CAD applications software were not great requiring primary reliance on developing our own. According to reports in Reference material [36], in 1979-1983 the International Standardization Organization had not yet issued new MMT standards. When formulating national standards, the U.S., England, France, and the Soviet Union selectively adopted and implemented some 13 international standards for huatai [3323 0669] made public in 1972-1977. Of course, when conditions permit, we can consider importing a small quantity of applications software for reference purposes.

4. Intensify coordination inside and outside the industry.

Establishing an MMT CAD system requires a great deal of work and it is necessary to organize forces both inside and outside the industry and to coordinate the division of labor to be able to set it up rapidly in a short period of time. It should be pointed out in particular that domestic institutions of higher learning have very strong technological forces and in carrying out MMT CAD development research work should establish various types of cooperative relations between each other to fully bring them into play and better combine theory and practice. During the Sixth 5-Year Plan, many units of the MMT industry established good cooperative relationships with institutions of higher education in the CAD area and this laid a good foundation for future cooperation.

5. At the same time as developmental research we should stress promoting applications, and in the process of promoting applications should form an industry CAD technological rank.

There is a very large volume of MMT CAD technology developmental research work, and if we wait for all development to be completed before promoting applications we are bound to have to wait a very long time. On completing developmental research on a piece of software we could immediately promote its applications as much as possible to obtain practical results promptly. At the same time, in the processing of promoting applications, we can also further improve the software developed and train and organize an industry CAD contingent.

In terms of the specific methods for organizing CAD technology developmental research, we feel:

1. MMT CAD applications software system should adopt a modular structure.

Currently, on the basis of many years of design experience, MMT design units have carried out a specialized division of labor in the areas of MMT design, the interrelations between them are very clear, the design methods of the areas are very mature, the adoption of a modular structure conforms to existing design rules, is beneficial for summarizing current design experience and will facilitate the control and use of design personnel. At the same time, MMT design includes the industrial processing, machinery, hydraulics, and electrical specializations and they are both independent of one another as well as closely linked. The modular structure will be beneficial to differentiating between inter-area and intra-area data and information. In addition, the suitable digital models which it is difficult to establish for the design of many parts in MMT design require use of man-machine dialogue to differing degrees, and a modular structure also will be beneficial to clarifying the man-machine interface of the parts. In addition, modular structure can also make CAD software systems more flexible, so that they can both carry out design of entire machines as well as carry out independently the design of a certain part of an MMT. In arranging research work, modular structure will also be beneficial for going from easy to difficulty, coordinating the division of labor, and help gradually transplanting to microcomputers and promoting applications.

2. For such specialized support software as databases and graphics libraries required by MMT CAD, we should consider first, establishing in the design modules specialized databases and graphics libraries (such as a database of performance parameters and graphics library of generally used MMT parts, MMT electrical systems and hydraulic systems database and graphics library, etc.) then as necessary and possible combine them into a unified database and graphics library system. Adopting the above method is based on: the long-standing specialized division of labor within MMT design has been clear, the databases and graphics libraries used for the parts are very standardized, even the standard parts and generally used spare parts are fixed or have specific ranges, thus establishing specialized databases will satisfy demands of CAD for parts under most circumstances. Planning and establishing a large-scale database takes a great deal of work, and although in China there are

imported database management systems and graphics systems, almost none of them have been digested and secondary development completed. Thus, establishing a large-scale database and graphics library will take a very long time. If it is not established properly it can increase the difficulty of developing the CAD applications software. By establishing a small-scale special purpose database and graphics library we can accumulate more experience and it is beneficial for promotion and application.

On the basis of the current MMT design situation, we feel that with MMT industrial processing and structure proposal design modules and the kernel, we can consider developing MMT cutting use selection and cutting force calculations, support design of beds and chassis, multiple spindle box design, machine tool instruction writing, machine tool precision testing standards and inspection certificate writing, hydraulic system design, electrical system design, jig design, and cutting tool design modules, and establish MMT cutting parameter database, general purpose part performance parameter database, multiple spindle box design database, guide and cutting auxiliary tools database, hydraulic design database and electrical design database, and general purpose parts, guide and cutting auxiliary tools, hydraulic, and electrical graphics libraries, to satisfy the basic demand for developing MMT CAD.

3. We should do more "three izations" of MMTs.

The "three izations" foundation of MMT is very good. Currently there are 13 national standards, 62 part level standards, and over 100 design manuals, more than 2,000 large and small general purpose parts and components are in use, the design databases are basically complete, thus excellent conditions have been created for developing CAD developmental research and establishing various databases and graphics libraries. However, there are some parts, such as multiple spindle boxes and intermediate chassis, for which standardization and serialization have not yet been completed. Thus, it is necessary to do more "three izations" work in MMTs as quickly as possible. Otherwise, it will create very large difficulties for MMT CAD technology developmental research and even lead to sizeable waste of manpower and materials.

4. We should pay attention to combining CAD and CAM.

Currently, the tendency abroad for MMT CAD to develop towards CAD/CAM systems and CAE is very clear. Furthermore, many components in CAD and CAM use similar digital, shape and characteristics information. Thus, in the process of developing CAD software we should take note of this issue and consider the matter of combining CAD and CAM. Otherwise, when we carry out CAD in the future we may create much duplicate conversion and processing of information, waste a great deal of manpower and time, and have an impact on further development of MMT CAD technology.

In summary, applications research on developing CAD technology is an urgent mission for China's MMT industry today. During the Sixth 5-Year Plan, we did a great deal of work in this area and laid a foundation for further development. However, there is still a fairly large gap with the advanced world levels. This paper is a tentative viewpoint on how to develop China's

MMT CAD development research, and we present it for discussion and research by our comrades. The aim is only to reduce this gap so that China's MMT industry can adopt advanced CAD technology soon to adapt to the new situation in which China's machine building industry places ever greater demands on MMT and their automatic lines, ever shorter design cycle demands, and ever higher quality demands.

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METROLOGY WORK FOR 7TH 5-YEAR PLAN DISCUSSED

Beijing ZHONGGUO JILIANG [CHINA METROLOGY] in Chinese NO 11, NOv 86 pp 2-3

[Article by Zhou Zhuandian [0719 0278 0368], Ministry of Metallurgical Industry: "Strive For Good Metrology Work in the Seventh 5-Year Plan Period"; This article is excerpts from a speech given by Comrade Zhou Zhuandian at the Check and Acceptance Meeting for Setting the Level of Metrology of the Jinzhou Ferro-alloy Plant]

[Text] In the Sixth 5-Year Plan period our metallurgy system improved its knowledge of metrology work, perfected metrology organizations at all levels, improved in a preliminary way metrology inspection facilities, established metrology management systems and made great advances. However, we should note that these advances can only be said to have had excellent beginnings. We still have much metrology work that should be continued and even at plants with a national first rank metrology unit, such as the Jinzhou Ferroalloy Plant, there is still much work to do and plants which are not of a first level metrology unit the work that must be done is even greater. I have three hopes on how to make greater improvements in metrology work during the Seventh 5-Year Plan which I present for your consideration.

First, Metrology work during the Seventh 5-Year Plan period should make promoting improvement in product quality one of its main goals. In the past few years, leadership comrades such as Xiaoping, Yaobang, Ziyang, and Chen Yun have issued numerous directives on improving product quality. Last year Comrade Xiaoping said: In industrial production, including export products, the focus should be on stressing product quality and making quality first. Products which are inferior to the quality of the past will not be exported, only products of good quality have promise of export. In the critical issue of quality, we should strengthen quality control agencies, and collect a group of specialists to do this work. In August of this year when Comrade Xiaoping was inspecting Tianjin he said: The issue of quality is of utmost importance.

At this Steel Quality Conference, industries carried out surveys of quality control work in their plants on the basis of the directions of the central committee leadership comrades. Everyone felt that the past few years, our understanding of quality was not sufficiently strong and placed the quantity of products in a prominent position while in planning, quality has been discussed in terms of the rate of qualifying. What does rate of qualifying mean? Rate of qualifying means 60 percent. If we say that we are satisfied by achieving 60 percent, then the demand is too low and we should keep on improving! If ye go abroad and ask people what the rate of qualifying is

they will say, products that don't qualify cannot leave the plant. Wherever things don't qualify, people do not have this idea that things can leave the plant so this is a deficiency in our planning work. This year Premier Zhao said that we demand that in 2 or 3 years the quality of our important products reach international levels, some reach international general levels, some to reach international advanced levels. We understand that to achieve international advanced levels is to reach the level of material goods abroad. At our Steel Quality Planning Conference, everyone recognized that Comrade Ziyang's goal of 40-50 percent production according to international norms can be achieved, but that it requires the resolution of a problem, and that is, changing from the practice of separation of norms, quality and price to their integration and the implementation of high quality and good price. At this quality conference we analyzed the current situation in terms of quality and as soon as we made a comparison with other countries we saw the gap. Our planning management is poor: we have not placed quality at the head of planning work as others have done; the chemical composition of the steel is poor, we are not as strict as others, the content of harmful elements both fluctuates highly and is large and cannot compare with others'; the purity of the steel is deficient, it contains impurities; the dimensional tolerances are large and the surface is not smooth. Planning management is a problem of knowledge, but composition, purity, physical properties, dimensional tolerances, and surface smoothness are problems of metrology, and all stem from the use of metering devices for measurement. If we say that our metrology work of the past 5 years has improved the level of scientific operation so that production developed in a balanced and stable way is because meterological data has played a very great role as the basis, then the work involved in improving product quality has not been large enough and the role played has not been great either. Thus, from now on we should take our lead from the directives of the central committee leadership comrades on improving product quality and must further improve metrology work. Only if metrology improves and is strictly controlled can we adopt new technology and promote the improvement of product quality. The five areas of steel products quality I just mentioned are judged by meterological standards and if they are not strictly controlled then there will be defects and it cannot meet international standards. Thus, improving product quality is a key emphasis in Seventh 5-Year Plan metrology work.

Second, Although our metrology work has made great advances in 5 years, development has been very uneven. In terms of the metallurgy industry, you in Liaoning Province are the first unit to achieve first rank metrology levels, but this steel mill, Anshan, Fushun and Dalian steel mills and the Liaoyang Ferroalloy Plant have not yet become first rank metrology units and there is still a deficiency. On the foundation of the Sixth 5-Year plan we should further improve metrology work. In terms of the above, you have achieved first rank metrology level, and the other plants which also should enter the level of first rank metrology units must improve.

Earlier the Metrology Office of the ministry carried out a survey. I saw their survey report. In similar furnaces and machinery, the metering instruments were not entirely the same: some had more, some had less, and a few were incomplete. In addition, the accuracy of some metering instruments was good, the accuracy of some was poor; inaccuracy cannot play a role and

sometimes can even play a negative role. Weighing of materials is relatively complete, industrial processing monitoring and product quality inspection systems are deficient, thus what scale do we use to measure quality? It has been pointed out at this quality conference that inspection systems should definitely be complete. The state has stipulated that those items achieving international norms can have their prices increased by 15 percent, those achieving international advanced levels can have their prices increased by 35 percent, and this was formally decided by the National Standards Conference. However, achieving international standards or international advanced standards requires perfected inspection methods, and facilities should be complete. Measuring those foreign standards by our methods, chemical composition, physical properties, purity, tolerances, and surface smoothness should all meet the stipulations, and this is a problem of metrology. In the past we put emphasis on measuring materials flow, because this technique was incomplete, there was no way for plant management to figure accounts clearly. Subsequently, we also paid attention to inspecting such industrial processes as temperature, flow, and pressure, and because these things were incomplete, there was no way to control process flow scientifically. However, we do not have such high regard for industrial process inspection as we do for metering materials flow, therefore we still need to strengthen it. As concerns inspection of product quality, which is not regarded highly enough, such as steel rails and steel tubing, we should have on-line inspection and carry out non-destructive flaw detection in the production process which in many of our plants is incomplete so that we cannot discuss organizing production according to international advanced levels.

Third, Metrology technology should be at a high level, i.e., metrology work should be further combined with computers and should be computerized. At the computer conference convened this year, Comrade Wan Li made an important comment in which there is an incisive conclusion: there is no modernization without computerization. Therefore to speak of the Four Modernizations without mentioning computers is only empty talk. Abroad, industrialization and computerization developed simultaneously. It isn't underestimating our abilities, it's only that we are too far behind. Last month I visited England and France and everything I saw made me heave another sigh and I felt anxiety. The (Daiwei) Company in England has a design department which uses computer-aided design and has 2,500 computers and over 2,700 personnel. (Our entire metallurgy system has more than 3 million persons, but according to figures from the end of last year we had only 2,100 computers.) One computer for each person, some desks had a terminal and a microcomputer, that's complete computerization. On the return trip when I passed through Hong Kong, I visited the Huifeng Bank, their more than 12,000 personnel had over 5,000 computers. When I speak of computerization I am referring to banking, design, research, and industrial process control having computers. I am currently the head of the computer leading group in the ministry and I am also a member of the National Computer Committee so I am very ashamed that I have not completed my responsibility and catching up so sluggishly will not do.

Only after general metrology work has been improved can we use computers, using computers is a high level stage of metrology, and if the metrology is imperfect, then the computers are of no use. Computers are not mysterious. I asked the chairman of the board of the Huifeng Bank, How did you train your

personnel to use the more than 5,000 computers? He said, After studying for three weeks or a month, people who have graduated from university and high school basically have a good understanding, so then we give them a microcomputer and they learn while they are using it and they learn how very quickly. Of course hardware repair is not something easily learned, but using the hardware is easily learned. After metrology work has been improved, we should immediately use computers for developing a high first rank metrology. First are the sensors,then the instrumentation system, and then input into the computer. We view these three elements as component parts of metrology work. There is no modernization if we cannot carry out these three steps. I hope that our metrology work will struggle for a few years on the foundation of the Sixth 5-Year Plan and further perfect and improve, and cannot just go on with the same old stuff. The same old stuff is backward and cannot advance.

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PSEUDO-SYMMETRIC SETS, RELATED GEOMETRIC INEQUALITIES

Beijing SHUXUE XUEBAO [ACTA MATHEMATICA SINICA] in Chinese Vol 29, No 6, Nov 86 pp 802-806

[Article by Yang Lu [2799 6424] and Zhang Jingzhong [1728 2529 0022]]

[Text] Introduction

This paper addresses the problem of "symmetry" of the distribution of N points in E^n space. For example, in E^3, when $N \neq 4,6,8,12,20$, the N points cannot be all the vertices of a regular polyhedron; but can their distribution still have certain symmetry? This is a problem which arises in trying to establish the condition of equality of certain geometric inequalities. For a large class of geometric inequalities of a point set G [7], the condition of equality is that the ellipsoid of inertia of G about its center of gravity must be a sphere. The authors call such a point set "inertially equilateral"; this term implies a certain sense of symmetry of the point set. For many other geometric inequalities, the condition of equality is established when the point set possesses "symmetries" of different types or different degrees.

In this paper, the concept of E^n pseudo-symmetry, which is a stronger symmetry condition that the "inertially equilateral" condition, is introduced; related geometric inequalities are also established. In addition, the algebraic characteristics of a pseudo-symmetric finite set are discussed and a new criterion for distinguishing the hyper-spherical surface from other surfaces is obtained by applying the discrete results to a compact surface.

Let $\mathcal{F}$ be a compact surface in E^n, and F be the area of $\mathcal{F}$. Let

$$M_1(\mathcal{F}) = \frac{1}{F^2}\int_{\mathcal{F}}\int_{\mathcal{F}} |x-y|^2 d\sigma(x) d\sigma(y)$$

be the "power of chords average" of $\mathcal{F}$, the authors have proved the inequality

$$M_1(\mathcal{F}) \geqslant \frac{n+1}{n} M_1^2(\mathcal{F}),$$

the equality sign holds if and only if $\mathcal{F}$ is a hypersphere.

§ 1. Pseudo-symmetry and Distrete Geometric Inequality

Definition 1 Let G be a point set in n-dimensional Euclidean space, we say that G is E^n-psuedo-symmetric if the convex closure is of dimension n, and

(i) all the points in $\mathcal{G}$ are distributed in a sphere S^{n-1} in E^n;

(ii) the center 0 of the sphere S^{n-1} coincides with the center of gravity of the set $\mathcal{G}$.

(iii) the ellipsoid of inertia of $\mathcal{G}$ about 0 is a sphere.

Based on this definition, the following two conclusions are readily obtained:

Lemma 1 The set of all vertices of an n-dimensional regular poly-hedron is E^n-pseudo-symmetric. The set of all points on an n-1 dimensional sphere is E^n-pseudo-symmetric.

Lemma 2 If $\mathcal{G}$ and $\mathcal{G}^*$ are both E^n-pseudo-symmetric, and $\mathcal{G}$ and $\mathcal{G}^*$ are distributed on the same spherical surface, then their union $\mathcal{G} \cup \mathcal{G}^*$ is also E^n-pseudo-symmetric.

Now we shall derive a geometric property of the pseudo-symmetric set.

Let $\mathcal{G} = \{x_1, x_2, \cdots, x_N\}$ be a finite subset of E^n, let $|x_i - x_j|$ denote the Euclidean distance between two points x_i, x_j; also let M_r denote the average value of the rth power of these distances

$$M_r(\mathcal{G}) = \frac{2}{N(N-1)} \sum_{1 \le i < j \le N} |x_i - x_j|^r. \tag{1}$$

Noting that $x_i - x_j = 0$, equation (1) can be written as

$$M_r(\mathcal{G}) = \frac{1}{N(N-1)} \sum_{i=1}^{N} \sum_{j=1}^{N} |x_i - x_j|^r.$$

Let G be the center of gravity of the point set $\mathcal{G}$, and let

$$a_i = |x_i - G| \quad (i = 1, \cdots, N) \tag{2}$$

be the distance from x_i to G. Also, let

$$L(\mathcal{G}) = \frac{2}{N(N-1)} \sum_{1 \le i < j \le N} (a_i^2 - a_j^2)^2 \tag{3}$$

represent the average value of $(a_i^2 - a_j^2)^2$

We shall now establish the following:

Theorem 1 For any finite point set $\mathcal{G}$ in E^n consisting of N points (N > n), the following inequality holds:

$$M_4(\mathcal{G}) \ge \frac{N-1}{N} \frac{n+1}{n} M_2^2(\mathcal{G}) + L(\mathcal{G}) \tag{4}$$

here, a sufficient and necessary condition for the equality sign to hold is: the ellipsoid of inertia of $\mathcal{G}$ about its center of gravity is a sphere.

The proof of this theorem will make use of Lemma 3 described below, which is a special case of well-known result. Let N_1 denote the sum of the squares of

distances between all the points in $\mathcal{G}$, let Δ_N denote the sum of the squares of areas of all the triangles whose vertices are the points in $\mathcal{G}$. Then we have:

Lemma 3 (see equation (1.5) in Ref. [7]). For any finite point set $\mathcal{G}$ and $\mathcal{G}$ containing N elements, the following inequality holds:

$$N \geq \frac{4\pi}{\sigma - 1} \sqrt{N}, \tag{5}$$

and the sufficient and necessary condition for the equality sign to hold is: the ellipsoid of inertia of $\mathcal{G}$ about its center of gravity is a sphere.

Proof of Theorem 1. Let $a_{ij} = |x_i - x_j|$, and let $I(x_i)$ denote the moment of inertia of $\mathcal{G}$ about x_i, i.e.,

$$I(x_i) = \sum_{j=1}^{N} a_{ij}^2, \quad i = 1, \cdots, N. \tag{6}$$

Also, let $I(G)$ denote the moment of inertia of $\mathcal{G}$ about the center of gravity G. It is a well-known fact that

$$I(x_i) = I(G) + N|x_i - G|^2. \tag{7}$$

therefore,

$$\sum_{1 \leq i < j \leq N} (I(x_i) - I(x_j))^2 = N \sum_{1 \leq i < j \leq N} (a_{ij}^2 - a_{ji}^2)^2 = \frac{N^2(N-1)}{2} I(\mathcal{G}). \tag{8}$$

also,

$$\begin{aligned} \left(\sum_{1 \leq i < j \leq N} a_{ij}^2 \right)^2 &= \frac{1}{4} \left(\sum_{i=1}^{N} \left(\sum_{j=1}^{N} a_{ij}^2 \right) \right)^2 \\ &= \frac{N}{4} \left(\sum_{i=1}^{N} \left(\sum_{j=1}^{N} a_{ij}^4 \right) \right) - \frac{1}{4} \sum_{1 \leq i < j \leq N} \left(\sum_{k=1}^{N} a_{ik}^2 - \sum_{k=1}^{N} a_{jk}^2 \right)^2 \\ &= \frac{N}{4} \left(\sum_{i=1}^{N} \left(\sum_{j=1}^{N} a_{ij}^4 \right) \right) - \frac{1}{4} \sum_{1 \leq i < j \leq N} (I(x_i) - I(x_j))^2. \end{aligned} \tag{9}$$

now let Δ_{ijk} denote the area of a triangle whose vertices are x_i, x_j, x_k. using the familiar area formula, we have:

$$\begin{aligned} 16 \sum_{1 \leq i < j < k \leq N} \Delta_{ijk}^2 &= \sum_{1 \leq i < j < k \leq N} (2a_{ij}^2 a_{ik}^2 + 2a_{ij}^2 a_{jk}^2 + 2a_{ik}^2 a_{jk}^2 - a_{ij}^4 - a_{ik}^4 - a_{jk}^4) \\ &= 2 \sum_{i=1}^{N} \left(\sum_{1 \leq j < k \leq N} a_{ij}^2 a_{ik}^2 \right) - (N-2) \sum_{1 \leq i < j \leq N} a_{ij}^4. \end{aligned}$$

thus,

$$2 \sum_{i=1}^{N} \left(\sum_{1 \leq j < k \leq N} a_{ij}^2 a_{ik}^2 \right) = (N-2) \sum_{1 \leq i < j \leq N} a_{ij}^4 + 16 N_4. \tag{10}$$

Substituting equations (8) and (10) into equation (9) and rearranging, we obtain:

$$N^2 = \frac{N^2}{4} \sum_{1 \leq i < j \leq N} a_{ij}^4 + 4N N_4 - \frac{N^2(N-1)}{8} I(\mathcal{G}). \tag{11}$$

This is the inequality (4) we set out to prove. With regard to the condition for equality, since the inequality sign only appears in (3), the condition of equality is the same for (3) as for (4). This condition is: the ellipsoid of inertia of $\mathcal{G}$ about its center of gravity is a sphere.

Theorem 1a. For any finite point set $\mathcal{G}$ in E^n consisting of N points ($N \geq n$), the following inequality holds:

$$M_2(\mathcal{G}) \geq \frac{n-1}{n} \frac{N+1}{N} V^2(\mathcal{G}) \tag{12}$$

The equality sign holds if and only if $\mathcal{G}$ is pseudo-symmetric.

Proof: The sufficient and necessary condition for (12) to hold is that the inequality (3) holds, and $\mathcal{G} \neq \mathcal{F}$. Clearly $I(\mathcal{G}) \neq 0$ is equivalent to condition (a) and (c), and the condition of equality of (4) is equivalent to condition (b).

Our theorem establishes an inequality relationship between the 4th power average and 2nd power average of the distances between all points; and the condition of equality is exactly the pseudo-symmetric property defined above.

4. Inequality for Compact Surfaces

Let $\mathcal{F}$ be a compact surface in E^n, and $\mathcal{V}$ be the area of $\mathcal{F}$. Let the center of gravity of $\mathcal{F}$ be chosen as the origin of the coordinate system. We use the following quantity $I(\mathcal{F})$ as a measure of the distance between $\mathcal{F}$ and the hypersphere:

$$I(\mathcal{F}) = \frac{1}{\mathcal{V}^2} \int_{\mathcal{F}} \int_{\mathcal{F}} (|x|^2 - |y|^2)^2 d\sigma(x) d\sigma(y). \tag{13}$$

Also, let $M_2(\mathcal{F})$ be the 4th power of chords average of $\mathcal{F}$, as indicated in the introduction. Then, by taking the limit of Theorem 1, one readily obtains:

Theorem 2. For any compact surface $\mathcal{F}$ in E^n, we have:

$$M_2(\mathcal{F}) - \frac{n-1}{n} M_1^2(\mathcal{F}) \geq I(\mathcal{F}) \tag{14}$$

As a corollary of this theorem, we can derive a new criterion for distinguishing a hypersurface from other surfaces.

Theorem 2a. For any compact surface $\mathcal{F}$ in E^n, we have:

$$M_2(\mathcal{F}) \geq \frac{n+1}{n} M_1^2(\mathcal{F}). \tag{15}$$

The equality sign holds if and only if $\mathcal{F}$ is a hypersphere.

It should be noted that the power of chords integral under consideration here is a double surface integral; it is different from the power of chords integral in classical integral geometry, I_r or J_r, where J_r is the double integral on a convex surface and $I_r = \frac{1}{2}\pi r(r-1) J_{r=-1}$. The problem of inequality between the powers of chords integrals $I_{r=n}$ or $J_{r=n}$ for a convex surface has always been an interesting topic. On the other hand, currently we still do not know how to extend the inequalities discussed in this paper to the general M_r.

§ 3. Algebraic Characteristics of a Pseudo-symmetric Finite Point Set

First, let us consider a point set which satisfies conditions (i) and (ii) of Definition1. Such point sets are of interest [1,2] because they yield extreme values for certain functionals. The set $\mathcal{G}$ and related notations are as described in § 1. In general, the N dimensional matrix (a_{ij}^2) is called the "square distance matrix" of $\mathcal{G}$; it has the same degree of importance as the Cayley-Menger matrix[3].

Definition 1 The characteristic polynomial of the square distance matrix of the finite point set $\mathcal{G}$, $f(\lambda)=\det|a_{ij}^2-\lambda E|$, is called the characteristic polynomial of $\mathcal{G}$. Also, the bordered determinant

$$g(\lambda)=\begin{vmatrix} 0 & 1 & 1 & \cdots & 1 \\ 1 & -\lambda & a_{12}^2 & \cdots & a_{1N}^2 \\ 1 & a_{21}^2 & -\lambda & \cdots & \\ \vdots & \vdots & & \ddots & \vdots \\ 1 & a_{N1}^2 & & & -\lambda \end{vmatrix} \tag{16}$$

is called the sub-characteristic polynomial of $\mathcal{G}$.

Lemma 4 Let $\mathcal{G}$ be an N-point set which satisfies conditions (i) and (ii). Then the following relationship exists between the characteristic polynomial and the sub-characteristic polynomial:

$$N f(\lambda)=(\lambda-c)g(\lambda). \tag{17}$$

where $c=2NR^2$, R is the radius of the spherical surface in $\mathcal{G}$.

Derivation of this lemma is omitted. From this result we can directly deduce the following:

Series 1. For an N-point set $\mathcal{G}$ which satisfies the conditions (i) and (ii), the roots of the sub-characteristic polynomial $g(\lambda)$ are also the roots of the characteristic polynomial $f(\lambda)$; furthermore, $f(\lambda)$ has an additional root equal to $2NR^2$.

To clearly understand the algebraic characteristics of a pseudo-symmetric set, the following lemma is also required.

Lemma 5 If the convex closure of a finite point set $\mathcal{G}$ is of dimension n, and the ellipsoid of inertia of $\mathcal{G}$ about its center of gravity is a sphere, then the sub-characteristic polynomial of $\mathcal{G}$ only has n non-zero roots which are equal to one another (n repeated roots).

This is a result which has been previously obtained, see corollary 4.1 of Ref.[8]. Now we shall establish the main theorem of this section.

Theorem 3 Let G be a N-point set ($N > n$), then the sufficient and necessary condition for G to be E^n-pseudo-symmetric is that the characteristic polynomial and sub-characteristic polynomial of G must obey the following relation:

$$Nf(\lambda) = (\lambda - c)g(\lambda),$$

and that $g(\lambda)$ only has n non-zero repeated roots.

Proof From Lemma 4 and Lemma 5, the necessity of this condition is quite obvious. Now we shall prove the sufficiency of this condition.

Let the n non-zero roots of $g(\lambda)$ be the repeated root λ_0. By expressing $g(\lambda)$ in the form of a polynomial expansion, and noting that all other roots of $g(\lambda)$ are zero, then from the relationship between roots and coefficients, one can readily obtain:

$$n\lambda_0 = -\frac{2}{N}\sum_{1\le i<j\le N} a_{ij}^2. \tag{18}$$

Next, consider the roots of $f(\lambda)$. In addition to all the roots of $g(\lambda)$, $f(\lambda)$ has the additional root c. Noting that the trace of the square distance matrix is necessary zero, it follows that the sum of all roots of $f(\lambda)$ is zero. Therefore,

$$c = -n\lambda_0. \tag{19}$$

Expanding the polynomial $f(\lambda)$ according to its definition, and noting that it has n roots equal to λ_0, one root equal to $-n\lambda_0$, and the rest of the roots equal to zero, one can readily obtain from the relationship between roots and coefficients:

$$\frac{n(n+1)}{2}\lambda_0^2 = \sum_{1\le i<j\le N} a_{ij}^4. \tag{20}$$

comparing (18) with (20) gives

$$M_4(G) = \frac{N-1}{N}\,\frac{n+1}{n}\cdot M_2^2(G),$$

it follows from Theorem 1 that G is E^n-pseudo-symmetric. Q.E.D.

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SPIN-LABELED DERIVATIVES OF TOXIN FROM PODOPHYLLUM VERSIPELLE, HCE. WITH ANTI-CANCER ACTIVITY

Beijing ZHONGGUO KEXUE (B JI) [SCIENTIA SINICA: SERIES B (CHEMICAL, BIOLOGICAL, AGRICULTURAL, MEDICAL & EARTH SCIENCES)] in Chinese No 11, 1986 pp 1205-1211

[Article by Chen Yaozu [7115 5069 4371], Zhang Changjiu [1728 7022 0036], and Tian Xuan [3944 2537] of Department of Chemistry, Lanzhou University]

[Abstract] Three types of spin-labeled derivatives (containing an NO free radical) from toxin in Podophyllum versipelle, Hce. with anti-cancer activity. As indicated in the preliminary pharmacology tests, these derivatives exhibit apparent inhibition against cancer cells of several animals in experiments, but the toxicity of the derivatives is much lower than the parent compound. There is a linear relationship between the relative intensities of the ESR signals of these labeled derivatives and their concentrations. Therefore, the electron spin resonance spectrum can serve in measuring the chemical concentrations in the blood and organs of mice or rabbits. Six diagrams show the synthesis pathway of spin-labeled derivatives, the ESR spectra of compounds GP-1 and GP-3, a linear relationship between their concentrations and ESR relative intensities, time-concentration curves of compounds in animal liver, kidney and blood, and drug distribution in organs 10 days after injecting drugs into tumor-transplanted mice. The authors are grateful to the pharmacology faculty research laboratory of the Lanzhou Medical College and the Beijing Institute of Tumor Treatment and Prevention for pharmacology experiments; and to the Lanzhou Institute of Chemical Engineering, Beijing Institute of Chemical Engineering, as well as trace and wavelength spectrum laboratories of Lanzhou University for elemental analysis and measurement of optical spectram. The first draft of the paper was received on 21 May 1984; the final, revised draft was received for publication on 22 March 1986.

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WATER STRUCTURE OF DE-PENTAPEPTIDE (B26-30) INSULIN CRYSTALS WITH 1.5 Å DISCRIMINABILITY

Beijing ZHONGGUO KEXUE (B JI) [SCIENTIA SINICA: SERIES B (CHEMICAL, BIOLOGICAL, AGRICULTURAL, MEDICAL & EARTH SCIENCES)] in Chinese No 11, 1986 pp 1167-1178

[Article by Dai Jinbi [2071 6855 3880], Lou Meizhen [2869 5019 3791], You Junming [3266 0193 2494], and Liang Dongcai [2733 2767 2624] of Institute of Biophysics, Chinese Academy of Sciences, Beijing]

[Abstract] This paper reports on water structure of de-pentapeptide (B26-30) insulin (DPI) crystals of 1.5 Å discriminability. Based on examination of the last ($2F_o$-F_c) Fourier diagram of the expanded F_o, the discussed water model includes 81 water molecules (electron density > 0.4 e/Å^3), about two-thirds of the crystal solvent. In the hydrogen-bond range between 2.4 and 3.2 Å, 51 water molecules and protein atoms form hydrogen bonds at 63 percent of water, including 12 protein molecules with single water molecule bridging the adjacent protein molecules, and more protein molecules with double water molecules bridging adjacent protein molecules. There is a compact water network in the one long, narrow seam between the protein molecules; through three water molecules (ligands), two Cd atoms support this water network like wooden pilings at both terminals. This indicates the importance of Cd atoms and water network in the dense deposition of molecules.

Five diagrams show the electron density, distributions of DPI molecular bonds, their radicals and water molecules, distribution of the shortest distances between protein and oxygen atoms in water, Fourier overlapping of Cd coordination, and its connecting water network. Five tables list statistical data of water structure models in DPI crystal, distribution of number of water molecules, hydrogen bonds between water and principal bonds (and side bonds), and classification of water molecules with their hydrogen bonds combined with protein.

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DIRECT CALCULATION FROM VERTICAL SECTION DIAGRAM OF Bi-Sn-Zn TERNARY ALLOY SYSTEM

Beijing ZHONGGUO KEXUE (B JI) [SCIENTIA SINICA: SERIES B (CHEMICAL, BIOLOGICAL, AGRICULTURAL, MEDICAL & EARTH SCIENCES)] in Chinese No 11, 1986 pp 1143-1149

[Article by Fu Zezhong [0265 0463 6945] and Zhao Muyu [6392 1970 1946] of Department of Chemistry, Jilin University; and Xu Baokun [1776 1405 3824] of Department of Electronics, Jilin University, Changchun]

[Abstract] The vertical-section diagram can clearly reveal phase variations in a system with given constituents at equilibrium with change in termperature. So the vertical-section diagram has broad and important applications in metallurgy, chemical engineering, silicate industry and chemistry research.

Based on the adjacent phase region and the boundary relationship in a phase diagram, the paper proposes a direct and simple calculation method using the vertical-section in a constant pressure phase diagram. This method was used to compute the vertical-section of different types and positions in the Bi-Sn-Zn ternary system constant-pressure phase diagram. Six diagrams show four vertical sections, Bi-Sn-Zn experimental phase, computation of positions of the vertical-section of several constants, and the positions of three types of vertical-section plane.

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THEORY OF RESONANT SELF-FOCUSING

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 36 No 1, Jan 87 pp 1-9

[English abstract of article by Ma Jinxiu [7456 6930 4423], et al., of Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences]

[Text] In the present paper, by using optical mixing and self-focusing theory, the resonant self-focusing effect of two parallel propagating laser beams with frequency differences equal to the plasma oscillation frequency in a homogeneous plasma is studied theoretically. The nonlinear dielectric constant and the threshold power for resonant self-focusing are derived analytically. The scaling laws of the threshold power with respect to laser-plasma parameters are discussed and compared with those of the usual ponderomotive self-focusing. Finally, the effect of the deviation from frequency matching conditions on the threshold power is also studied.

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LASER-INDUCED DAMAGE IN $LiNbO_3$:Fe

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 36 No 1, Jan 87 pp 24-28

[English abstract of article by Wu Zhongkang [0702 0112 1660], et al., of the Department of Physics, Nankai University, Tianjin; Xu Liangying [1776 5328 3847] of Shanghai Institute of Ceramics, Chinese Academy of Sciences; Xu Yuheng [1776 3768 1854] of the Department of Chemistry, Harbin University of Technology]

[Text] The authors have investigated the surface damage induced by a visible laser in $LiNbO_3$:Fe. The laser damage tracks (glide lines and microcracks) and microdomains are produced at the +c side of the periphery of light-illuminated regions. These microdomains arise at laser damage tracks and at cylindrical grooves on the surface of the sample. The authors also found that these damage defects in LN.Fe can be decorated by space-charges due to a photovoltaic effect and they are directly observable between crossed polarizers. The role of the cavity field, the electrostatic repulsive fprce at the domain boundary and self-enhanced diffraction light induced by physical imperfections on laser-induced surface damage are discussed.

CSO: 4009/33

EQUATION OF MOTION OF MAGNETIC DOMAIN WALLS IN COMPOSED EXTERNAL FIELD AND ITS APPLICATION TO MAGNETOELASTIC INTERNAL FRICTION

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 36 No 1, Jan 87 pp 37-46

[English abstract of article by Zeng Wenguang [2582 2429 0342], et al., of the Department of Physics, Zhongshan University, Guangzhou]

[Text] It has been found that the forces on the domain walls (DW_s) in ferromagnetic material for measuring internal friction (IF) when the magnetic field (H) is increased at a constant rate (α) are: (1) the main driving force caused by the H, namely $A_0^0 + A_1^0\alpha t$; (2) the harmonic perturbation force $A_3^0\sin\omega t$; (3) the interaction force which is proportional to $A_1^0\alpha t$, $A_3^0\sin\omega t$ and a resistant force depending on the internal stress field and anisotropy field $A_2^0 t\sin\omega t$. The equation of motion of DW_s can be written as

$$\rho\frac{d^2x}{dt^2} + \gamma\frac{dx}{dt} + \kappa\chi = A_0^0 + A_1^0\alpha t + A_2^0 t\sin\omega + A_3^0\sin\omega t$$

where A_0^0, A_1^0, A_2^0, A_3^0 are constants depending on the material chosen and test conditions; ρ is the mass density, γ is the viscous damping parameter and κ is the coefficient of restoring force. The IF caused by DW_s motion can be obtained from the solution of the equation of motion as follows:

$$Q_m^{-1} = B_1\frac{E\lambda_s\delta}{M_s^2H_m}\frac{dM}{dH}\cdot\frac{\alpha}{\omega} \quad (\text{If for } \alpha \neq 0)$$

$$Q_0^{-1} = B_2\frac{\gamma\omega E}{\kappa^2} \quad (\text{If for } \alpha = 0)$$

where E is the modulus, λ_s is the saturation magnetostriction, M_s is the saturation magnetization, H_m is a critical field at which the reversible motion of DW_s becomes irreversible, B_1, B_2 are dimensionless positive numbers. When $\alpha \neq 0$, the visco-elastic IF may be initiated and the IF varies with α/ω; when $\alpha = 0$, the low-frequency micro-eddy current IF may be initiated and the IF varies with ω.

The calculated results are compared with those of experimental data and interface dynamics.

CSO: 4009/33

TEMPERATURE FIELD CONTROL MODEL OF LASER CRYSTALLIZATION OF HYDROGENATED AMORPHOUS Si

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 36 No 1, Jan 87 pp 74-77

[English abstract of article by Bao Ximao [7637 1585 5399], et al., of the Department of Physics, Nanjing University]

[Text] During Ar^+ laser scanning at low speeds, four kinds of crystallization zones appear on a-Si:H films deposited on quartz substrates. They are the microcrystalline phase zone, solid phase zone, supercooled liquid phase zone and liquid phase laser zone brown by liquid phase transverse epitaxies. The temperature field control model of laser crystallization of hydrogenated amorphous silicon has been proposed by which the crystallization processes and their features can be explained.

CSO: 4009/33

INFLUENCE OF SUBSTITUTION OF TRANSITION ELEMENTS FOR BORON ON INDUCED MAGNETIC ANISOTROPY IN COBALT BASE AMORPHOUS ALLOYS

Beijing WULI XUEBAO [ACTA PHYSICA SINICA] in Chinese Vol 36 No 1, Jan 87 pp 95-100

[English abstract of article by Wang Qun [3769 5028], et al., of the Department of Materials Science, Northeast University of Technology, Shenyang]

[Text] The substitution effect of a few percent of V and Nb for boron in cobalt base amorphous alloys on induced magnetic anisotropy has been investigated. Disk shape samples have been subjected to isothermal magnetic annealing in the temperature range of 260-320°C. The kinetic curves of the formation of induced anisotropy have been measured with a sensitive torque-magnetometer and the kinetic parameters have been calculated by assuming that the distribution of relaxation time obeys a log-normal law. These results show that substitution of vanadium or neobium for boron in cobalt amorphous alloys can reduce the $K_U^{sm}(T)$ effectively, but only has a very slight effect on the kinetic parameters. The problems of the influences of transition metal additions on the induced magnetic anisotropy and stability are discussed.

CSO: 4009/33

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APPLICATION OF ENERGY CONSERVATION LAW TO CALCULATION OF DIRECTIVITY FUNCTIONS

Beijing SHENGXUE XUEBAO [ACTA ACUSTICA] in Chinese Vol 12 No 2, Mar 87 pp 132-143

[English abstract of article by Lan Jun [5695 6511] of the Institute of Acoustics, Chinese Academy of Sciences]

[Text] Concepts of the effective aperture and beamwidth are proposed based on the energy conservation law. Through these concepts the sound field distribution may be associated with the array configuration, and the pressure in the mainbeam direction, directivity factor and mainbeam width may be united.

The effective aperture and effective beamwidth of the arrays with larger dimensions are computed and the following regularities are obtained: The effective beamwidth of a plane array equals the reciprocal of its area (measured by λ); the effective beamwidth of a curve array is approximately equal to the central angle of the curve array and is approximately a constant beamwidth; the effective beamwidth of a compensated curve array is approximately equal to its area of projection into the compensated direction.
(Received 26 Nov 84.)

CSO: 4009/35

MEASUREMENT OF INPUT MECHANICAL IMPEDANCE OF PLANE ARRAY ELEMENT USING IMPULSE SOUND TUBE

Beijing SHENGXUE XUEBAO [ACTA ACUSTICA] in Chinese Vol 12 No 2, Mar 87 pp 144-147

[English abstract of article by Ren Shuchu [0117 2885 0443], et al., of the Institute of Acoustics, Chinese Academy of Sciences]

[Text] In this paper, a method of measuring the input mechanical impedance of the array element (longitudinal vibrating transducer) with square radiation head by using an impulse sound tube is proposed. The resonant frequencies determined from the measured input mechanical impedance are in agreement with those obtained from the electrical admittance circle diagram of the element. This indirectly shows that the method is feasible. (Received 12 Dec 84.)

CSO: 4009/35

TEMPERATURE DEPENDENCE OF SOUND ABSORPTION IN SEA WATER DUE TO MAGNESIUM SULFATE

Beijing SHENGXUE XUEBAO [ACTA ACUSTICA] in Chinese Vol 12 No 2, Mar 87
pp 151-154

[English abstract of article by Qiu Xinfang [5941 6580 2455], et al., of the Institute of Acoustics, Chinese Academy of Sciences]

[Text] In this paper, the expressions for relaxation frequency and maximum absorption per wavelength of the $MgSO_4$ relaxation as a function of temperature are presented based on the data of sound absorption in natural sea water measured by the reverberation method at 27 different temperatures between 4 and 29°C. (Received 24 Nov 84.)

CSO: 4009/35

EFFECT OF DIRECT INTERBAND TUNNELING ON CHARACTERISTICS OF LONG-WAVELENGTH $Hg_{1-x}Cd_xTe$ PN JUNCTION

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 6 No 1, Feb 87 pp 3-14

[English abstract of article by Yuan Haoxin [5913 4110 1800], et al., of Shanghai Institute of Technical Physics, Chinese Academy of Sciences]

[Text] Based on Kane's model of tunneling current and considering the influence of the Fermi-Dirac distribution function, expressions of direct interband tunneling current and the tunneling-limited (R_0A) product are deduced. The calculated results for $Hg_{0.8}Cd_{0.2}Te$ PN junction show that the direct interband tunneling is an important current mechanism which limits junction characteristics. The effects of this current mechanism on I-V characteristics and the R_0A product of the $Hg_{0.8}Cd_{0.2}Te$ PN junction, as well as their dependence on P- and N-side doping concentration and operating temperature, are analyzed. Comparisons of the N^+P and P^+N configurations are given. In order to calculate the tunneling current, the quasi Fermi levels on both sides of the junction are also calculated.

CSO: 4009/36

INFLUENCE OF PEIZOELECTRIC-RESONANCE ON PERFORMANCES OF PYROELECTRIC $LiTaO_3$ INFRARED DETECTORS

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 6 No 1, Feb 87 pp 35-44

[English abstract of article by Fang Hubao [2455 3275 1405], et al., of the Department of Technical Physics, Northwest Telecommunication Engineering Institute]

[Text] The influence of thickness-mode piezoelectric-resonance on performances of pyroelectric $LiTaO_3$ infrared detectors is discussed by one-dimensional heat conduction and thermodynamic theories. The resonance is observed by means of piezoelectric measurement. The theoretical calculations show that the detector noise is apparently increased near the resonance frequency, but the responsivity increases by two orders of magnitude and the noise equivalent power decreases one order of magnitude. In order to match well with the detector, the coupling resistance of the preamplifier should be chosen from 10^3 to 10^5 Ω.

CSO: 4009/36

STUDY OF DISTRIBUTION OF PRINCIPAL STRESSES IN SILICON CRYSTAL BY INFRARED PHOTOELASTIC METHOD

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 6 No 1, Feb 87 pp 45-49

[English abstract of article by Zhao Shounan [6392 1108 0589], et al., of the Department of Physics, South China Institute of Technology]

[Text] Quantitative measurement for principal stresses σ_1 and σ_2 in silicon crystal is made with the infrared photoelastic equipment built by the authors. In order to measure the stresses as accurately as possible, the tensor of the piezo-optical coefficient of stress in some coordinate systems of a diamond structure is derived. The relative stress-optical coefficient of the silicon crystal is estimated. By the shearing stress difference principle, the distribution curves of the two principal stresses along the diameter of silicon wafers are plotted with a microcomputer.

CSO: 4009/36

PARAMETERS FOR CHARACTERIZING FAR-INFRARED VIDEO DETECTORS

Shanghai HONGWAI YANJIU [CHINESE JOURNAL OF INFRARED RESEARCH] in Chinese
Vol 6 No 1, Feb 87 pp 51-58

[English abstract of article by Gong Yaqian [7895 7161 6197] of Shanghai Institute of Technical Physics, Chinese Academy of Sciences]

[Text] It is pointed out that responsivity to radiation power, $R_{P\nu}$, and noise equivalent power, NEP(ν), are not good parameters for characterizing far-infrared video detectors when sizes of the detector components are not orders of magnitude greater than the operating wavelengths. Based on the theory of the angular spectrum of plane waves, it is shown that responsivity to the flux density, $R_{F\nu}$, antenna pattern, $P_{n\nu}(\theta, \varphi)$, noise equivalent flux density, NEF(ν) are parameters for characterizing the performances of far-infrared video detectors for radiometric applications. Methods of measuring these parameters are briefly described. Typical measured results of InSb far-infrared hot electron bolometers are given.

CSO: 4009/36

ABLATION OF CHARRED MATERIALS IN IONIZED AIR ENVIRONMENT

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese Vol 4, No 4, Dec 86 pp 352-360

[Article by Wei Shuru [7614 0647 1172], Wang Fuhan [3769 4395 3352], and Feng Guohuan [7458 0948 3883]]

[Text] Notations:

$B' = \dot{m}_w / \rho_e u_e C_M$ $B'_c = \dot{m}_c / \rho_e u_e C_M$ $B'_g = \dot{m}_g / \rho_e u_e C_M$ $B'_0 = \dot{m}_w / \rho_e u_e C_{M0}$	mass transfer parameters
C_{Ki}	atomic number of the K element in the ith constitutent
C_{pi}	constant-pressure specific heat of the ith constitutent
$\hat{C}_p = \sum K_i C_{pi}$	frozen specific heat
h	static enthalpy
h_a	internal enthalpy of ablation material
h_i	enthalpy of the ith constituent
h_i^0	enthalpy of generation of the ith constitutent
H_r	recovery of enthalpy
K_i	mass fraction of the ith constitutent
$\tilde{K}_k = \sum a_{ki} K_i$	total mass fraction of the K element of all the constituents
$\tilde{K}_{Kc}$	mass fraction of the K element in the charred layer
$\tilde{K}_{Kg}$	mass fraction of the K element in the pyrolyzed gas
K_{Pi}	equilibrium constant of the generation reaction of the ith constituent
M_i	molecular weight of the ith constituent
$\dot{m}_w = \dot{m}_c + \dot{m}_g$	

N_i, N_K	chemical notations
P	pressure
r	cross-sectional radius of the body of revolution
R_N	nose radius
S	surface coordinate
T	temperature
X_i	mol fraction of the ith constituent

Greek letters

$a^* = \rho, u, \mu, r/\sqrt{2\xi}$

a_{Ki}	mass fraction of the K element in the ith constituent
λ	heat conductivity
μ	coefficient of viscosity
$\xi = \int_0^s \rho, u, \mu, r^2 ds$	coordinate transformation
ρ	density
σ	Stefan-Boltzman constant
ϵ_w	surface emissivity

Subscript

c	carbon, cold wall
e	outer edge of the boundary layer
g	pyrolyzed gas
i	the ith constituent
K	the K element
w	wall surface
o	unablated

Superscript

*	solid state material
+	positive ion
-	negative ion

I. Introduction

Charred materials (including graphite, carbon-carbon, carbon-phenol-formaldehyde, and nylon-phenol-formaldehyde) are used as heat shield materials on high-performance warheads. Since the ablation processes of these materials all produce a solid charred layer on the surface, the thermochemical mechanisms of the ablation processes are basically the same. Therefore, the same methods can be used for calculating the ablation parameters.

Under steady or quasi-steady ablation conditions, the calculation of ablation parameters of charred materials involves calculating the parameters at the interface between the ablation surface and the gas boundary layer. A general treatment of this problem is to find a coupled solution of the ablation surface and the boundary layer of the reacting gas. Clearly, this is mathematically a very complicated approach. By removing or relaxing this coupling effect using the method of transfer coefficients, the computational procedure can be greatly simplified. But the conventional transfer coefficient incidence formulas do not take into account the effect of chemical reactions, hence they are not applicable for solving this problem. The transfer coefficient formulas used in this paper are derived by fitting the coupled solution of the stagnation-point ablation surface and the boundary layer of the reacting gas[7]; they not only meet the accuracy requirements but are also quite simple computationally. The purpose of this paper is to apply the method of transfer coefficients to calculate the ablation parameters of charred materials in ionized air environment.

II. Transfer Coefficients

The transfer coefficients include both the mass transfer coefficient and the heat transfer coefficient, which are defined respectively by the diffusion mass flow and the heat flux of the element $\tilde{K}_K$ at the interface. Thus, the mass transfer coefficient C_M is defined by:

$$\tilde{j}_{K_w} = -\rho_e u_e C_M (\tilde{K}_{K_e} - \tilde{K}_{K_w}) \tag{2-1}$$

where $\tilde{j}_{K_w}$ is the diffusion mass flow of the element K_K at the interface.

The heat transfer coefficient C_H is defined by the heat flux $[-q_w]$ into the ablation surface, i.e.,

$$[-q_w] = \rho_e u_e C_H (H_e - h_w) \tag{2-2}$$

The non-ablation heat transfer coefficient C_{H_0} is defined by the non-ablation heat flux $[-q_w]_0$, i.e.,

$$[-q_w]_0 = \rho_e u_e C_{H_0} (H_e - h_w) \tag{2-3}$$

When the wall temperature T_w is equal to 298.15 K (JANA ground state), we have

$$[-q_w]_{0c} = \rho_e u_e C_{H_0} H_e \tag{2-4}$$

where $[-q_w]_{0c}$ is called the non-ablation "cold wall" heat flux.

The early transfer coefficient incidence formulas were derived from the boundary layer solutions of air-air injection[1,2] or from simple thin-film theory[3-6,18] with empirical corrections. The results of coupled calculations of multiple charred materials in Ref. [7] show that the above formulas are inaccurate. For this reason, they derived a set of new incidence formulas by fitting the stagnation-point coupled solutions as follows:

$$C_M/C_{M_e} = B'_c/B' = \varphi_w/(e^{\varphi_w}-1) \tag{2-5}$$

$$\left.\begin{aligned} \varphi_w &= 2\lambda_w B'_c \\ \lambda_w &= (1.012 - 0.018 B'_c + 0.0814 B'^2_c)(1.0 - F_i) \\ F_i &= (0.238 + 0.033 B'_c)\left(\frac{F_c - 0.95}{0.6}\right)^{1/2} \end{aligned}\right\} \tag{2-6}$$

$$F_c = \begin{cases} 0.95 & \bar{M}_e/\bar{M}_w \le 0.95 \\ \bar{M}_e/\bar{M}_w & 0.95 < \bar{M}_e/\bar{M}_w < 1.55 \\ 1.55 & \bar{M}_e/\bar{M}_w \ge 1.55 \end{cases}$$

$$\begin{bmatrix} q_w \\ q_c \end{bmatrix} = \frac{C_M}{C_{M_e}}(1 - h_w/H_e) + \psi(1 - h_w/H_e) + \Delta H_c/H_e \tag{2-7}$$

$$\psi = 1.0 - 0.8563 B'_c + 0.01794 B'^2_c + 0.06365 B'^3_c - 0.01125 B'^4_c \tag{2-8}$$

$$\Delta H_c = \begin{cases} 0 & B'_c \le 0.17 \\ -606 + 1578(B'_c - 0.87) + 503(B'_c - 0.87)^2 & 0.17 < B'_c \le 0.87 \\ 606 - 805(B'_c - 0.87)^2 - 183(B'_c - 0.87)^3 & 0.87 < B'_c < 1.85 \\ 0 & B'_c \ge 1.85 \end{cases} \tag{2-9}$$

For graphite or carbon-carbon materials, $\Delta H_c = 0$, thus

$$C_H/C_{H_e} = \psi \tag{2-10}$$

The largest discrepancy between the above formulas and the coupled calculations is within 5 percent. While the formulas are based on fitting the stagnation-point coupled solutions, they have also been shown to be in good agreement with non-similar coupled solutions for non-stagnation point laminar and turbulent flows[7].

III. Thermo-Chemical Model

At the interface between the ablation surface and the boundary layer of the reacting gas, there are not only homogeneous reactions between gaseous constituents, but also heterogeneous reactions between gas and carbon. It has been shown that at an altitude of the re-entry vehicle where the problems of communication black-out and heat shield design are of interest, both homogeneous and heterogeneous reactions can be treated by using equilibrium relations[5-8].

Assume that the gas layer is a system consisting of I gaseous constituents (with K elements). Since nuclear reactions are not being considered, conservation of elements in the system can provide K conditions (equations) for

determining the composition of the gas constituents. But to completely determine the composition of I constituents requires additional (I-K) equations, which can be provided by the chemical equilibrium relations. Based on the principle of chemical equilibrium, the system only has (I-K) independent chemical reactions from which one can write (I-K) independent equilibrium relations. It should be pointed out that the choice of these (I-K) chemical reactions is arbitrary. For convenience, they are chosen to be the reactions of generating the (I-K) molecule or ion constituents from the K element constituents. Furthermore, since the contents of carbon and other elements (e.g., small amounts of alkaline sodium, etc.) in the solid charred layers are known, there is only one independent heterogeneous reaction (or condensed-phase generation reaction).

The general form of the generation reaction of the ith gas constitutent is:

$$\sum_{k}' C_{k,i} N_k \longrightarrow N_i \tag{3-1}$$

and the equilibrium relation is:

$$K_i = N_i / [P_e^{\sum' C_{k,i}} \Pi N_k^{C_{k,i}}] \tag{3-2}$$

The general form of the heterogeneous reaction is:

$$\sum_{k}' C_{k,s} N_k \longrightarrow N_s \tag{3-3}$$

and the equilibrium relation is:

$$K_s = [P_e^{\sum' C_{k,s}} \Pi N_k^{C_{k,s}}] \tag{3-4}$$

If the sublimation of solid state carbon is chosen as the heterogeneous reaction, then equations (3-3) and (3-4) reduce to the simple expressions:

$$C \longrightarrow C^* \tag{3-5}$$

$$K_s = P_e N \tag{3-6}$$

The number of constituents considered in the calculation is generally determined by a compromise between the accuracy requirements and the complexity of the computational procedure. Our guideline is to choose the smallest possible number of constituents within the range of accuracy requirement. In the following, we shall use the example of simple ablation of carbon-carbon material to illustrate the selection of constituents and the calculation of ablation parameters.

In calculating the carbon-carbon ablation parameters, we consider a total of 20 constituents:

$O_2, O, N_2, N, NO, NO^+, e^-$

$CO, CO_2, CN, C_2N_2, C_3, C_2, C$ (C_4, C_5, C_3N_2)

C^+, C^-, CO^+

Na, NaO, Na^+

The basis for this choice is as follows: It has been shown from ionized air calculations that the 7 air constituents are the most economical choice to meet general engineering requirements[9-12]. The choice of carbon constituents in carbon-carbon ablation calculations has been a controversial topic, but Refs. [5,6,13,14] have concluded from both analytical calculations and experiments that it is adequate to consider only the 10 constituents listed in the 2d row above. In our calculations, we also considered these 10 constituents initially, but we found that the computation of gas composition can be greatly simplified by ignoring the constitutents containing more than 4 carbon atoms with only minor degradation of the results; therefore, they are eliminated in subsequent calculations. The reason for choosing the 3 constituents C^+, C^-, and CO^+ is to investigate the contribution of the most probable carbon ion constituents to the electron density. Na, NaO and Na^+ are the most probable sodium constituents during the ablation of carbon-carbon materials which contain small amounts of alkaline sodium[14,23].

IV. Computational Equations

In the calculation of steady or quasi-steady ablation parameters of charred materials, there are total of (I + K + 4) basic unknowns including K_{kw} (K-1 unknowns), X_{iw} (I unknowns) and B'_Q, B', T_w, h_w, $\bar{M}_w$ and other unknowns that can be derived from the above quantities. The corresponding equations include the transfer coefficient formulas, the chemical equilibrium relations, the relations of conservation of elements, and the conservation of mass and energy at the interface. In this example, K = 5 (they are O, N, C, Na and e^-), I = 20, therefore, the number of unknowns is (I + K + 4) = 29; the corresponding equations include the transfer coefficient relations (2-5), (2-8), (2-7) or (2-10), the chemical equilibrium relations (3-2) and (3-6) as well as the following relations:

(1) conservation of elements (K - 1 = 4):

$$\hat{K}_{k,e} = \frac{M_k}{M_e} \sum_i C_{ki} X_{ie} \tag{4-1}$$

(2) equilibrium of electric charge (replacing $(\hat{K}_{i,e})_e = 1.0 - \sum_{k=1}^{K-1} \hat{K}_{k,e}$),

$$\cdot(\cdot X) - \cdot(\cdot X) = \cdot(\cdot X) \tag{4-2}$$

(3) conservation of mass at the gas-solid interface (K - 1 = 4):

Consider the control volume at the interface in Figure 1, one can write the equation of conservation of mass as follows:

$$\dot{m}_e \tilde{K}_e + \dot{m}_c \tilde{K}_c - \tilde{j}_{K_e} - \dot{m}_w \tilde{K}_w = 0 \qquad (4\text{-}3.a)$$

Substituting equation (2-1) into this equqtion and rearranging gives:

$$\tilde{K}_w = (\tilde{K}_e + B'_c \tilde{K}_c + B'_g \tilde{K}_g)/(1 + B') \qquad (4\text{-}3.b)$$

For the carbon-carbon material, $\dot{m}_g = 0$, therfore $\dot{m}_w = \dot{m}_c$, $B' = B'_c$. The subscript K in equations (4-1) and (4-3b) denotes O, N, C or Na.

(4) conservation of energy at the gas-solid interface (one equation):

Consider the control volume at the gas-solid interface (see Figure 2), one can write the equation of conservation of energy as follows:

$$[-q_w] + \dot{m}_c h_w + \dot{m}_g h_w - \dot{m}_w h_w - \varepsilon_w \sigma T_w^4 - \left[-\lambda_w \frac{dT}{dy}\right] = 0 \qquad (4\text{-}4.a)$$

Also. the conservation of energy for an internal control volume of the ablation body gives:

$$\dot{m}_w h_w + \left[-\lambda_w \frac{dT}{dy}\right] - \dot{m}_c h_w - \dot{m}_g h_w = 0 \qquad (4\text{-}4.b)$$

By combining equations (4.4.a) and (4-4.b) and substituting equations (2-2) and (2-8), one obtains:

$$0.01125 B_c'^2 - 0.06365 B_c'^3 - 0.01794 B_c'^4 + \left(0.6563 + \frac{h_w - h_e}{H_e - h_w}\right) B_c' + [\varepsilon_w \sigma T_w^4 / \rho_e u_e C_{H_e} (H_e - h_w) - 1.0] = 0 \qquad (4\text{-}5)$$

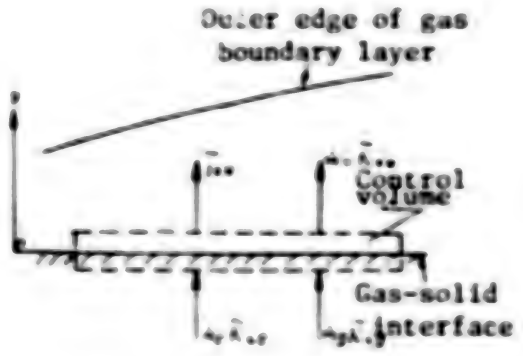

Figure 1. Conservation of Mass at the Gas-Solid Interface

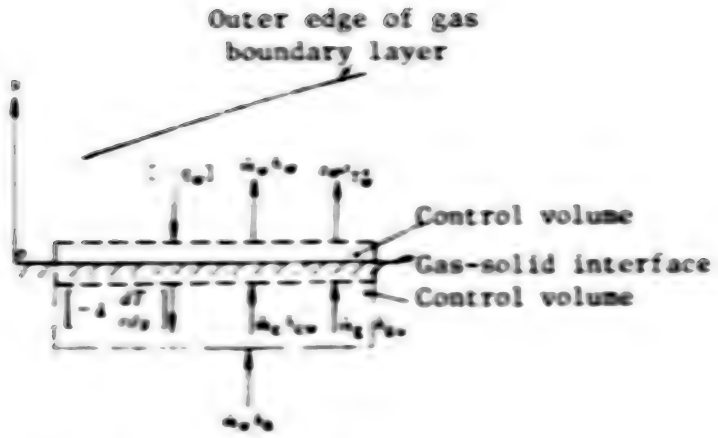

Figure 2. Conservation of Energy at the Gas-Solid Interface

(5) From the definitions of h_w, $\bar{M}_w$, we have

$$h_w = \sum (K_i h_i)_w = \frac{1}{\bar{M}_w} \sum X_{iw} M_i \left(\int_{T_r}^{T_w} C_{pi}\, dT + h_i^r \right) \tag{4-6}$$

$$\bar{M}_w = \sum X_{iw} M_i = 1 \Big/ \left(\sum K_{iw}/M_i \right) \tag{4-7}$$

The above equations constitute a set of closed algebraic equations; the following table shows the relations between the equations and unknowns.

Unknowns		Equations	
Name	Number	Equation No	Number
B_1', B'	2	(2-5), (4-5)	2
$\tilde{K}_{iw}$	$K-1=4$	(4-2,5)	$K-1=4$
X_{iw}	$J=20$	(3-2), (4-1), (4-2)	$(J-K)+(K-1)+1+J=20$
T_w, h_w, $\bar{M}_w$	3	(3-6), (4-6), (4-7)	3
Total	29	Total	29

These equations can be reduced to several 4th order algebraic equations whose solution can be obtained by iteration, and other parameters of interest can then be determined, e.g.,

$$\dot{m}_w = \rho_e u_e C_{H_e} B_1' \tag{4-8}$$

$$f_w = -\dot{m}_w / a^* \tag{4-9}$$

The gas electron density at the wall surface $(n_e^-)_w$ is given by:

$$(n_e^-)_w = (X_{e^-})_w P_w N_A / RT_w = 7.243568 \times 10^{21} \cdot P_w (X_{e^-})_w / T_w \quad [1/cm^3] \tag{4-10}$$

the electron collision frequency ν_c is [20]:

$$\nu_c = 5.738 \times 10^7 P_e / T_w^{3/2} \tag{4-11}$$

where N_0 is the Avogadro's constant; R is the conventional gas constant in units of J/mol-K; the unit of P_e is Pa; and the unit of T_w is degree K.

V. Numerical Results and Analysis

In order to test the validity of this method, calculations of the ablation boundary layer of carbon-carbon materials were carried out for the profile and flight conditions given in Ref. [14]; part of the results are shown in Figure 3-Figure 5. These calculations lead to the following results:

(1) If the calculations are based on the non-ablation heat flux obtained from the boundary layer of ionized air (or from the heat flux formula given in Ref. [17]), then the stagnation wall temperature T_w and the ablation rate $\dot{m}_w$ respectively 0.5 percent lower and 18 percent higher than the results given in Ref. [14]. If the calculations are based on the same non ablation heat flux as in Ref. [14], then the above discrepancies become respectively 10 percent and 6 percent, which are within the error bounds of the transfer coefficient incidence formulas and the various thermo-chemical data[7, 12,15,16].

(2) Because of the lack of consistent data, it is diffcult to provide a quantitative comparison of the non-stagnation results; however, the results of this paper are in excellent qualitative agreement with those of Refs. [7, 19]. Furthermore, as in Ref. [19], when S/R_n is large, $B' = \dot{m}_w/\rho_e u_e C_H$ approaches a constant value of 0.1800 (as shown in Figures 3 and 4). Therefore, the relatively simple method of this paper can produce results which are in good agreement with those of coupled calculations.

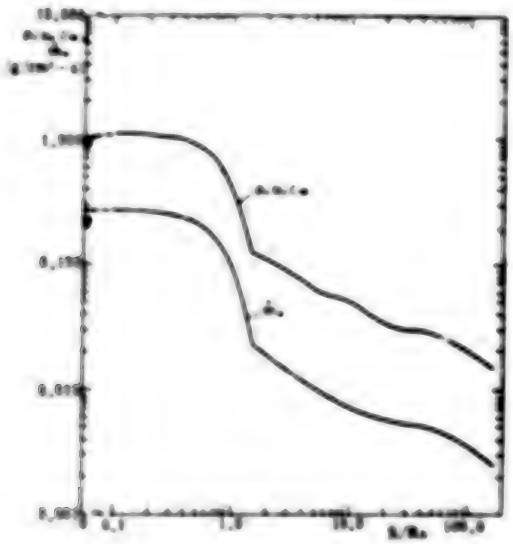

Figure 3. Variation of Ablation Rate and Mass Transfer Coefficient Along the Surface
—— this paper; ● Ref. [14]

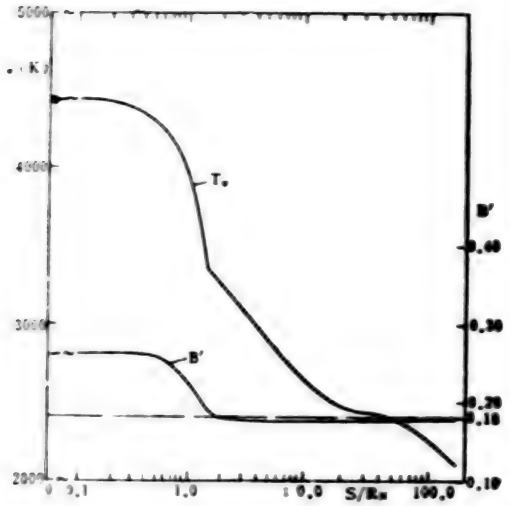

Figure 4. Variation of Wall Temperature and Mass Transfer Parameter Along the Surface
—— this paper; • Ref. [14]

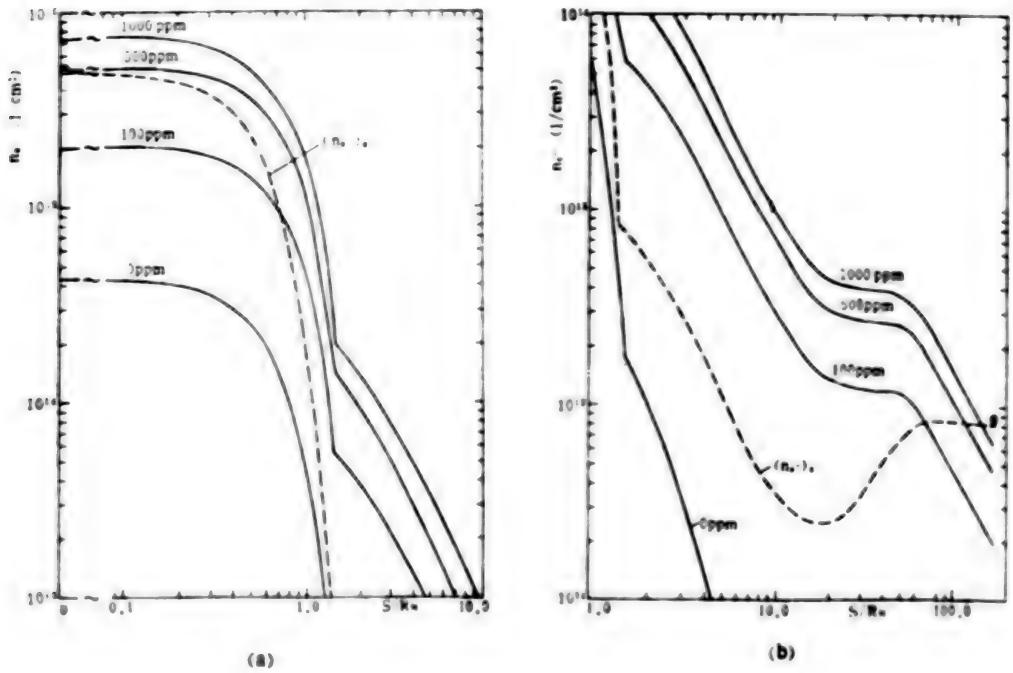

Figure 5. Variation of Electron Density Along the Surface
--- value at the outer edge of boundary layer;
• value at the outer edge given in Ref. [14]

(3) At the ablation surface, the ionization of alkaline sodium is the primary source of electrons in the gas layer; the ionizations of air and carbon constituents contribute very little. Consider an example where the sodium content is 100 ppm, at the stagnation point, the total contribution of NO^+,

CO^+, C^+ to the electron density is only 0.0016 percent; the contribution of the C^- ions to the reduction of electron density exceeds the total contributions of the positive ions, but it is only 0.44 percent. At non-stagnation points, the contributions of these ions are even smaller.

(4) In the numerical examples, when the contents of alkaline sodium are 100, 500 and 1000 ppm, the corresponding ratios of electron density at the ablation wall surface and in pure air with the same temperature are respectively 4.78, 11.89, and 17.25 in the stagnation region; but in the conic section these ratios can reach maximum values of 5551, 12876, and 18275. In other words, ablation can cause the electron density to increase by 3-4 orders of magnitude.

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3012/6091
CSO: 4008/30

IONIZED NONEQUILIBRIUM VISCOUS SHOCK LAYER FLOWS OVER BLUNT BODIES AT LOW REYNOLDS NUMBER

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese Vol 4, No 4, Dec 86 pp 380-388

[Article by Shen Jianwei [3088 1696 0251] and Qu Zhanghua [4234 4545 5478]]

[Text] I. Introduction

During re-entry flight, the effects of viscosity and shock compression cause the air to be decomposed and ionized, thus forming a plasma shield around the re-entry vehicle. To understand the flow field characteristics and the electron density distribution of re-entry flight plays a significant role in studying the problem of "communication black-out" and the "penetration" problem.

To determine the flow field by finding a numerical solution of the complete Navier-Stokes equations is not a practical engineering approach because solving a set of elliptical equations imposes very high requirements on computer storage and computing speed. Under high Reynolds number conditions, the viscous region adjacent to the wall surface can be described by the approximate boundary layer theory. However, at high altitudes during re-entry flight, the Reynolds number is quite low, and most of the shock layer region is affected by viscosity; thus the boundary layer method is no longer applicable. Davis[1] had proposed the method of viscous shock layer, where the flow region between the surface and the shock wave can be described by a set of unified governing equations. In order to overcome the improper behavior of the subsonic region in the numerical solution, he used the normal velocity cross-section obtained under the thin shock layer approximation as a supplemental condition.

The governing equations for the viscous shock layer are of the hyperbolic-parabolic type, which can be solved using the method of spatial progression. The equations retain all the non-viscous terms of the Navier-Stokes equations as well as the 2d order terms in the Reynolds parameter ε; thus the effects of viscosity and heat conduction are represented to a higher degree of accuracy than in the boundary layer equations. The external boundary conditions are given by the shock wave relations; the elliptical effect of unknown shock profile can be eliminated using the global iteration approach.

This article primarily discusses the nonequilibrium flow field in the nose region of a blunt body. To account for shock slip, the external boundary conditions are represented by the modified Rankine-Hugoniot relations. The numerical solution is carried out using a stable finite-difference method, with the stagnation point solution as the initial value. At the stagnation point, where a singularity of the equation exists, the method of limits must be used to find the solution.

II. Basic Equations and Boundary Conditions

1. Basic Equations

The governing equations for the non-equilibrium, viscous shock layer are derived by simplifying the equations for a gas mixture given by Bird, et al.[2] Expressed in a surface coordinate system, they are of the form (Figure 1):

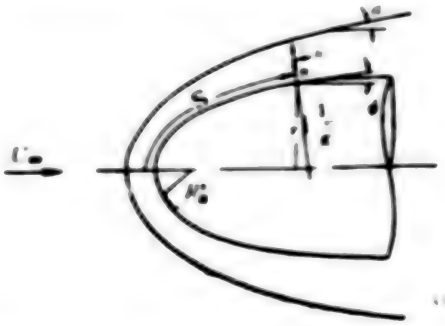

Figure 1. Surface Coordinate System

Continuity equation

$$\frac{\partial}{\partial s}(h_2\rho u)+\frac{\partial}{\partial n}(h_1h_2\rho v)=0$$

Momentum equation

$$\frac{\rho u}{h_1}\frac{\partial u}{\partial s}+\rho v\frac{\partial u}{\partial n}+\frac{\kappa}{h_1}\rho uv=-\frac{\partial p}{h_1\partial s}+\frac{\varepsilon^2}{h_1^2h_2}\frac{\partial}{\partial n}(h_2^2h_1\tau)$$

$$\frac{\rho u}{h_1}\frac{\partial v}{\partial s}+\rho v\frac{\partial v}{\partial n}-\frac{\kappa\rho u^2}{h_1}=-\frac{\partial p}{\partial n}$$

Energy equation

$$\frac{\rho uC_p}{h_1}\frac{\partial T}{\partial s}+\rho vC_p\frac{\partial T}{\partial n}-\frac{u}{h_1}\frac{\partial p}{\partial s}-v\frac{\partial p}{\partial n}=\frac{\varepsilon^2}{h_1h_2}\frac{\partial}{\partial n}(h_1h_2q)+$$

$$+\frac{\varepsilon^2}{\mu}\tau^2-\varepsilon^2\sum_{i=1}^{ns}J_iC_{pi}\frac{\partial T}{\partial n}-\sum_{i=1}^{ns}\dot{w}_ih_i \qquad (1.1)$$

Equation of constituents

$$\frac{\rho u}{h_1}\frac{\partial C_i}{\partial s}+\rho v\frac{\partial C_i}{\partial n}=\dot{w}_i-\frac{\varepsilon^2}{h_1h_2}\frac{\partial}{\partial n}(h_1h_2J_i),\ i=1,\cdots,ns$$

Equation of state

$$p=\frac{\rho RT}{\bar{M}\sum C_i}$$

where

$$h_1 = 1 + \kappa n; \quad h_2 = r + n\cos\phi; \quad \tau = \mu\left(\frac{\partial u}{\partial n} - \frac{\kappa u}{1 + \tau\kappa n}\right); \quad q = k\,\frac{\partial T}{\partial n}$$

$$J_i = \frac{-\mu Le_i}{Pr}\,\frac{\partial C_i}{\partial n}$$

$\bar{M}$ is the average molecular weight; Le_i is the Lewis number; $p = p^*/p^*_\infty$ is pressure; $\rho = \rho^*/\rho^*_\infty$ is density;

$$T = \frac{T^*}{(U^{*2}_\infty/C^*_{p_\infty})}$$

is temperature; $C_i = \rho_i/\rho$ is the constituent concentration; $u = u^*/U^*_\infty$, $v = v^*/U^*_\infty$ are the tangential and normal velocities respectively; $s = s^*/R^*_n$, $n = n^*/R^*_n$ are the tangential and normal coordinates respectively;

$$\varepsilon = \left(\frac{\mu(U^*_\infty/C^*_{p_\infty})}{\rho^*_\infty U^*_\infty R^*_n}\right)^{1/2}$$

is the Reynolds parameter; $\dot{w}_i$ is the constituent generation term; $h_i = h^*_i/U^{*2}_\infty$ is the static enthalpy; μ, k are the coefficient of viscosity and the heat conductivity respectively; the specific heat is

$$C_p = \sum_{i=1}^{N} C_i C_{p_i}$$

The superscript "*" denotes dimensional quantities, the subscript "∞" denotes free-stream reference conditions, and the subscript "i" denotes the constituent index.

2. Boundary Conditions

To account for shock slip, the external boundary conditions for the viscous shock layer are represented by the modified Rankine-Hugoniot relations[3]:

$$\rho_s \hat{v}_s = -\sin\alpha$$

$$\varepsilon^2 \mu_s \left(\frac{\partial \hat{u}}{\partial n}\right)_s + \sin\alpha\,\hat{u}_s = \sin\alpha\cos\alpha$$

$$p_s = p_\infty + \sin\alpha(\hat{v}_s + \sin\alpha)$$

$$\varepsilon^2 k_s \left(\frac{\partial T}{\partial s}\right)_s + \sin\alpha \sum_{i=1}^{N} C_{i_\infty} h_{i_s} - \frac{\sin\alpha}{2}[(\hat{u}_s - \cos\alpha)^2 +$$

$$+ \sin^2\alpha - v^2_s] = \sin\alpha \sum_{i=1}^{N} C_{i_\infty} h_{i_\infty} \qquad (1.2)$$

$$\varepsilon^2 \frac{\mu_s}{Pr} Le_i \left(\frac{\partial C_i}{\partial n}\right)_s + \sin\alpha\, C_{i_s} = \sin\alpha\, C_{i_\infty}$$

$$\rho_s = \frac{p_s \bar{M} C^*_{p_\infty}}{R T_s}$$

If shock slip is neglected, the partial derivatives in equation (1.2) reduce to zero. The superscript "^" denotes values in the shock reference system; the subscript "sh" denotes the shock wave; and α is the shock angle.

The wall slip conditions are given by:

$$
\begin{aligned}
&n=0,\ v=0\\
&u=\varepsilon^{1}a_{1}\frac{\mu}{\rho}\left[\frac{RT}{\tilde{M}C_{p}}\right]^{1/2}\left(\frac{\partial u}{\partial n}-\frac{\kappa u}{1+\kappa n}\right)\\
&T=T_{w}+\varepsilon^{1}C_{1}\frac{\mu}{\rho}\left[\frac{RT}{\tilde{M}C_{p}}\right]^{1/2}\frac{\partial T}{\partial n}
\end{aligned}
\tag{1.3}
$$

where a_1, C_1 are constants.[4]

If wall slip is ignored, then $a_1 = 0$, $C_1 = 0$.

With regard to constituent concentration, we have the following:

Fully catalytic wall condition: $C_{i}=C_{i}(T_{w})$ (1.4)

Non-catalytic wall condition: $\frac{\partial C_{i}}{\partial n}=0$

In the equation of constituent conservation and the energy equation, the generation term $\dot{w}_i$ and the term $\sum_{i=1}^{n} \dot{w}_i h_i$ are derived from the constituent concentration and the rate of chemical reaction. In the case of a multi-constituent non-equilibrium gas mixture, the equation of chemical reaction can be written in the generalized form:

$$
\sum_{i=1}^{n} a_{ri} X_i \underset{K_{b_r}}{\overset{K_{f_r}}{\rightleftharpoons}} \sum_{i=1}^{n} \beta_{ri} X_i, \quad r=1, \cdots, nr \tag{1.5}
$$

where the subscript r denotes the index of chemical reaction; X_i is the amount of the ith constituent or catalyst, nj is the total amount of constituents and catalysts; a_{r_i}, β_{r_i} are the coefficients of equivalent mass ratios; K_{f_r}, K_{b_r} are the forward and backward reaction rates. Thus,

$$
\frac{\dot{w}_i}{\rho} = M_i \sum_{r=1}^{nr} (\beta_{ri}-a_{ri})(L_{fr}-L_{br}) \tag{1.6}
$$

where

$$
L_{fr}=K_{f_r}\rho^{\left(\sum_{i=1}^{n} a_{ri}-1\right)}\prod_{i=1}^{n}(y_i)^{a_{ri}}
$$

$$
L_{br}=K_{b_r}\rho^{\left(\sum_{i=1}^{n} \beta_{ri}-1\right)}\prod_{i=1}^{n}(y_i)^{\beta_{ri}}
$$

$$\gamma_i = \frac{C_i}{M_i}\ ,\ j=1,\ \cdots,\ ns$$

$$K_{f_r} = T^{C1_r} \exp\left(C0_r - \frac{C1_r}{T}\right)$$

$$K_{b_r} = T^{C2_r} \exp\left(D0_r - \frac{D1_r}{T}\right)$$

where $C0_r$, ..., $D2_r$ are the constants corresponding to the equations of different chemical reactions, see Ref. [5].

The enthalpy h_i and specific heat C_{pi} of each constituent are obtained from the thermodynamic table given by Browne.[6] The coefficient of viscosity is given by the simulated curve:

$$\mu_i = \exp(C_i) T^{(A_i \ln T + B_i)} \qquad (1.7)$$

where A_i, B_i, C_i are constants.

To facilitate numerical calculations $\dot{w}_i$ and $\sum_{i=1}^{ns} \dot{w}_i h_i$ are expressed in terms of linear functions of C_i and T:

$$\dot{w}_i = \dot{w}_i^0 - \dot{w}_i^1 C_i$$

$$\sum_{i=1}^{ns} \dot{w}_i h_i = w_0 + w_1 T$$

Thus, the constituent equation and the energy equation can be written in the form of standard parabolic equations in the variables C_i and T.

III. Numerical Method

The numerical solution is carried out using a stable finite difference method, with the stagnation line solution as the initial value. In the subsonic $u < a$, the initial/boundary-value problem represented by equation (1.1) is improper; to overcome this difficulty, "artificial pressure" method is applied to the $\partial p/\partial s$ terms in the tangential momentum equation:

$$\left.\frac{\partial p}{\partial s}\right|_i = \omega_i \left.\frac{\partial p}{\partial s}\right|_i + (1-\omega_i) \left.\frac{\partial p}{\partial s}\right|_{i-1},\ 0 \le \omega_i < \frac{u}{a}$$

and "artificial velocity" method is applied to the $\partial v/\partial s$ terms in the normal momentum equation:

$$\left.\frac{\partial v}{\partial s}\right|_i = \omega_i \left.\frac{\partial v}{\partial s}\right|_i + (1-\omega_i) \left.\frac{\partial v}{\partial s}\right|_{i-1},\ 0 \le \omega_i < \frac{u}{a}$$

Here, i denotes the current value, and (i-1) denotes the previous value. Consequently, the structure of the coefficient matrix of the governing

equation is improved so that the proper conditions are satisfied. Also, $\omega_1 = \omega_2 = 0$ in the calculation.

The numerical solution is carried out in the (ξ, η) plane, where the transformation between the (s, n) plane and the (ξ, η) plane is defined by:

$$\xi = s$$

$$\eta = \frac{n}{n_{sh}}$$

The physical quantities are normalized with respect to values at the shock wave:

$$\bar{u} = \frac{u}{u_{sh}}; \quad \bar{p} = \frac{p}{\rho_{sh}}; \quad \bar{\rho} = \frac{\rho}{\rho_{sh}}; \quad \bar{T} = \frac{T}{T_{sh}}; \quad \bar{\mu} = \frac{\mu}{\mu_{sh}}; \quad \bar{k} = \frac{k}{k_{sh}}; \quad \bar{C}_{p_i} = \frac{C_{p_i}}{C_{p_{i,sh}}}$$

However, to avoid division by a small quantity or by zero, v and C_i are not normalized.

At the stagnation point, limiting relations $\xi \to 0, r \to \xi; \cos\phi \to \xi; u_{sh} = u_{sh,\xi}\xi$ are used to overcome the problem of singularity of the equation. The actual solution procedure is as follows: 1) the constituent equation, the energy equation and the tangential momentum equation are solved using the method of pursuit to obtain C_i, $\bar{T}$ and $\bar{u}$; 2) the continuity equation is integrated to obtain the shock distance n_{sh}; 3) the continuity equation is solved for v; 4) the normal momentum equation is integrated to obtain $\bar{p}$; 5) $\bar{\rho}$ is obtained from the equation of state. The above procedure is repeated until the convergence criterion is satisfied, and the solution progresses downstream.

In determining the solution, the shock angle a in the external boundary condition is also an unknown; this introduces elliptical effects in the computation which must be resolved using the method of global iteration. Specifically, for an analytical body, the shock wave is initially assumed to be parallel to the wall surface; after the first iteration, a new shock profile is obtained which will be used as the initial value for the next iteration. This procedure is repeated until the convergence criterion is satisfied. Numerical tests show that satisfactory results can be achieved with only three iterations.

IV. Results and Analysis

In this article, the flow field in the nose region of an axially symmetric hyperbolic body is calculated. The half cone angles of the blunt body considered are respectively 10°, 22.5°, and 30°. Calculations are carried out for different Reynolds numbers, and the results are presented in the following plots.

Figure 2 shows the stagnation line electron density distribution for different Reynolds numbers (Re). As Re increases, the level of Ne also increases. In other words, the level of electron density increases with decreasing flight

altitude. Figure 3 shows a comparison of the results of stagnation-line electron density distribution with those obtained by Lee and Zierten[7], where the free stream velocity is 7.01 km/sec and the nose radius is 1.71 cm. It is clear from the figure that the two results are in good agreement; the results given in this paper are somewhat higher.

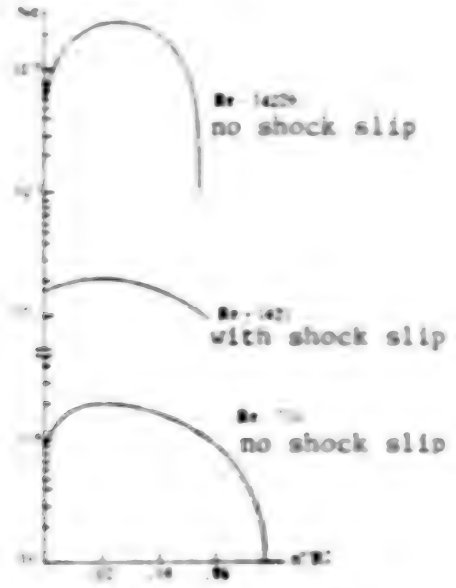

Figure 2. Electron Density Distribution at the Stagnation Point

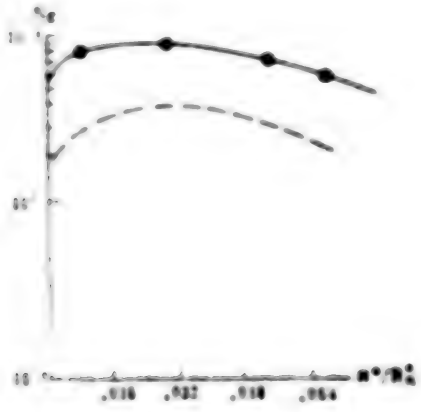

Figure 3. Electron Density Distribution

$U_\infty^* = 7.01$ km/sec; $R_0^* = 1.71$ cm; $T_w = 1800$ K; —— results of this article; ---- Ref. [7]

Figure 4 and Figure 5 are calculated results for the condition of no boundary slip and fully catalytic wall. The half cone angle is 22.5°, and the nose radius is 30.5 cm. The figures show that when chemical reactions are taken into consideration, the gas mixture still maintains the characteristics of a

perfect gas, with little variations in the coefficient of friction C_f or the Stanton number St. The results of Ref. [8] shown in figures correspond to the case of perfect gas flow.

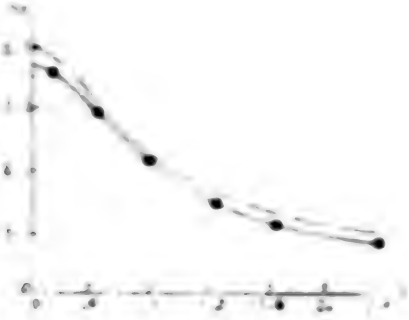

Figure 4. Distribution of Stanton Number

M_∞ = 21.57; T_∞ = 195.4 K; Re = 430; T_w/T_0 = 0.05; 22.5° hyperbolic body; —·— results of this paper; ---- Ref. [8]

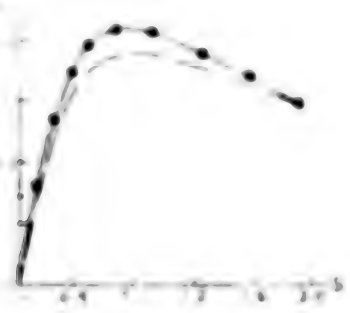

Figure 5. Distribution of Coefficient of Friction

M_∞ = 21.57; T_∞ = 195.4 K; Re = 430; T_w/T_0 = 0.05; 22.5° hyperbolic body; —·— results of this paper; ---- Ref. [8]

Figure 6 and Figure 7 are calculated results for Re = 14220. The half-cone angle is 10°, the nose radius is 67.1 cm, and the free-stream velocity is 7.65 km/sec. Figure 6 shows the distribution of constituent concentration at the stagnation point; Figure 7 shows the distribution of electron density at different locations. The level of Ne gradually decreases as the flow progresses downstream; at the stagnation line the level is as high as 10^{13}.

Figure 8 shows the effect of shock slip on electron density. With no shock slip, the Ne level behind the shock wave rapidly drops to zero; when shock slip is taken into consideration, Ne tends to a finite value, and the shock distance increases. Figure 9 shows the effect of wall slip on the Stanton number; Figure 10 shows the effect of wall catalyzation on electron density distribution. The level of Ne near the wall is highest under non-catalytic wall conditions.

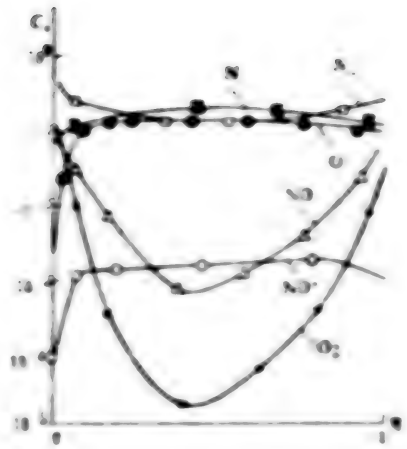

Figure 6. Distribution of Constituent Concentration at the Stagnation Point
Re = 14220; M_∞ = 24.6

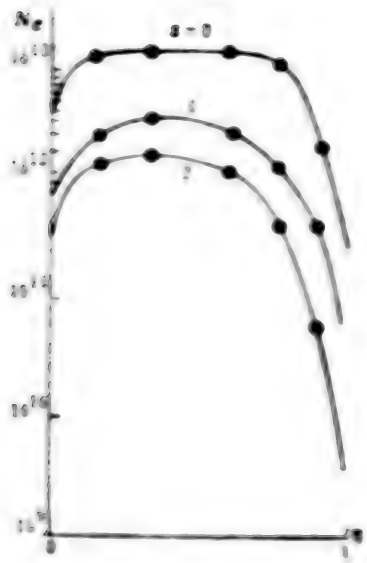

Figure 7. Distribution of Electron Density
Re = 14220; M_∞ = 24.6; no slip; half cone angle = 10°

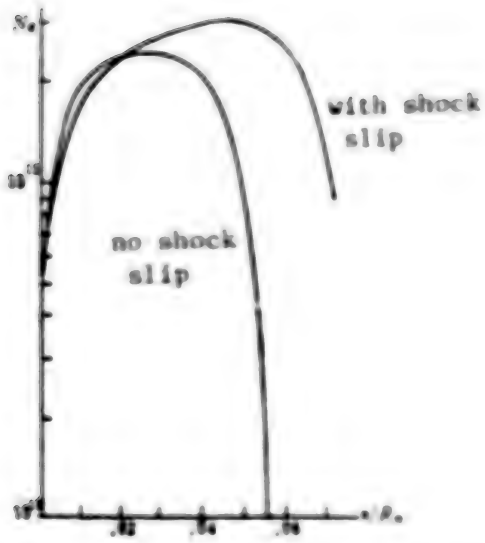

Figure 8. Distribution of Electron Density at the Stagnation Point
U_∞ = 7.65 km/sec; Re = 14220; half cone angle = 30°

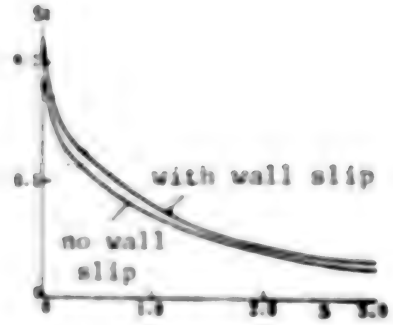

Figure 9. Distribution of Stanton Number
Re = 2615; R_n = 1.22 m; U_∞ = 7.62 km/sec; T_w = 1000 K; T_∞ = 180.9 K

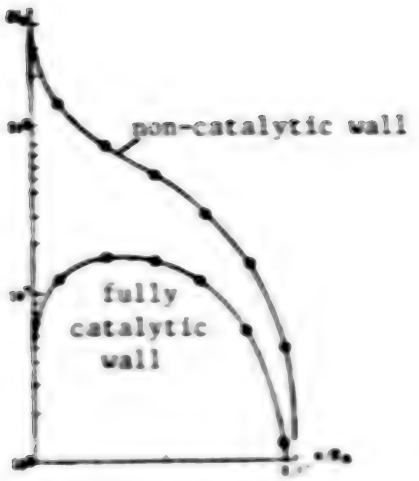

Figure 10. Distribution of Electron Density

Re = 319; U_∞ = 6.1 km/sec; T_w = 1500 K; T_∞ = 195 K; R_n = 2.54 cm; half cone angle = 22.5°

V. Conclusion

In this paper, numerical methods are used to calculate the flow field in the nose region of a viscous shock layer; the flow parameters and electron density distribution of a non-equilibrium flow are obtained. The conclusions reached in this paper are summarized below.

1. The viscous shock layer equations can be used to solve the problem of hypersonic flow over a blunt body for a wide range of Reynolds numbers; in particular, they are valid under high-altitude, low-Reynolds number conditions. After proper treatment of the equations, the calculations can start from the stagnation line and progress downstream. The difficulty of elliptical effects introduced by the unknown shape of the shock wave can be overcome by using the method of global iteration.

2. When chemical reactions are taken into consideration, the global characteristics of the gas mixture such as C_f, St, etc., do not differ significantly from those of perfect gas flow. In the flow field, the electron density is highest at the stagnation line, and gradually decreases as the flow progresses downstream.

3. When shock slip is taken into consideration, the shock distance increases and the electron density behind the shock wave rises; in addition, the surface transport coefficient is also affected.

4. The effect of wall catalyzation is primarily to change the distribution of constituent concentration in the vicinity of the wall surface.

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3012/6091
CSO: 4008/30

EXPERIMENTAL RESEARCH OF FAVORABLE INTERFERENCE IN JET FLOWS

Mianyang KONGQIDONGLIXUE XUEBAO [ACTA AERODYNAMICA SINICA] in Chinese Vol 4, No 4, Dec 86 pp 446-450

[Article by Dong Yuejuan [5516 2588 1227]]

[Text] Notations:

V	free stream velocity
ρ_∞	free stream density
M_∞	free stream Mach number
M_j	Mach number at jet exit
β_j	$= (M^2 - 1)^{1/2}$
P_j	static pressure at jet exit
P_∞	free stream static pressure
A_j	jet [illegible] area
A_∞	maximum [illegible]ss-sectional area of missile
R_j	gas constant of jet stream
R_∞	gas constant of free stream
T_j	jet stream temperature
T_∞	free stream temperature
γ_j	isentropic index of jet stream
γ_∞	isentropic index of free stream
p_j/p_∞	pressure drop ratio (the ratio between pressure at jet exit and free stream static pressure)
θ_j	shock angle
$\bar{c}$	relative thickness of the support frame cross section
r	missile roll angle
C_x	drag coefficient of the entire missile
C_{xb}	drag coefficient of the base section

Subscript

m denotes model

c denotes actual condition

1. Objectives of Experiment

A key issue which often affects the success or failure of a new aircraft or missile design is whether or not drag reduction can be achieved.

In the design of supersonic complex bodies powered by ramjet engines, a topic of great interest in drag research is to answer the questions: What is the effect of the tail jet stream from the side-mounted engines on the tail drag and the base drag of the missile body? Is it possible to take advantage of the favorable interference of the jet stream to design an optimum configuration of the afterbody?

The purpose of this experiment is to design four different afterbodies by taking into consideration the structure, mechanism and effects of the jet stream, and to select an optimum configuration of the afterbody based on the test results.

2. Similarity Parameters of the Jet Stream

The displacement effect of the jet stream depends on the shape of the jet boundary, particularly on its initial tilt angle. For small turning angles, one can take the first order terms of the pressure ratio series expansion to derive the similarity parameters between a model experiment and a full-scale experiment with the same flow turning angle, i.e.,

$$[(1-p_\infty/p_j)\beta_j/\gamma_j M_j^2]_m = [(1-p_\infty/p_j)\beta_j/\gamma_j M_j^2]_c \tag{1}$$

If the jet Mach number of the model is equal to that of the full-scale missile, then the following relation can be obtained:

$$\left[(1-p_\infty/p_j)\frac{1}{\gamma_j}\right]_m = \left[(1-p_\infty/p_j)\frac{1}{\gamma_j}\right]_c \tag{2}$$

If the jet static pressure of the model and the free-stream static pressure ratio are identical to the actual conditions, then:

$$\left[\frac{\gamma_j M_j^2}{\beta_j}\right]_m = \left[\frac{\gamma_j M_j^2}{\beta_j}\right]_c \tag{3}$$

Research results have shown that the ejection effect of a jet stream depends on the momentum ratio, the kinetic energy ratio, the ratio of flow rates as well as the mixing process between the jet stream and the free stream. For this reason, the following similarity relations are proposed:

momentum:
$$\begin{bmatrix} p_j \cdot \gamma_j \cdot M_j^2 \cdot A_j \end{bmatrix}_m = \begin{bmatrix} p_\infty \cdot \gamma_\infty \cdot M_\infty^2 \cdot A_\infty \end{bmatrix}_c \tag{4}$$

kinetic energy:
$$\begin{bmatrix} \gamma_j \cdot M_j^2 \cdot R_j \cdot T_j \\ \gamma_\infty \cdot M_\infty^2 \cdot R_\infty \cdot T_\infty \end{bmatrix}_m = \begin{bmatrix} \gamma_j \cdot R_j \cdot M_j^2 \cdot T_j \\ \gamma_\infty \cdot R_\infty \cdot M_\infty^2 \cdot T_\infty \end{bmatrix}_c \tag{5}$$

flow rate:
$$\begin{bmatrix} p_j \cdot M_j \cdot \gamma_j^{\frac{1}{2}} \cdot R_j^{-\frac{1}{2}} \cdot T_j^{-\frac{1}{2}} A_j \\ p_\infty \cdot M_\infty \cdot \gamma_\infty^{\frac{1}{2}} \cdot R_\infty^{-\frac{1}{2}} \cdot T_\infty^{-\frac{1}{2}} \cdot A_\infty \end{bmatrix}_m = \begin{bmatrix} p_\infty \cdot M_\infty \cdot \gamma_\infty^{\frac{1}{2}} R_\infty^{-\frac{1}{2}} T_\infty^{-\frac{1}{2}} A_\infty \\ p_\infty M_\infty \gamma_\infty^{\frac{1}{2}} R_\infty^{-\frac{1}{2}} T_\infty^{-\frac{1}{2}} A_\infty \end{bmatrix}_c \tag{6}$$

enthalpy:
$$\begin{bmatrix} (\gamma_\infty - 1) \cdot \gamma_j \cdot R_j \cdot T_j \\ (\gamma_j - 1) \gamma_\infty \cdot R_\infty \cdot T_\infty \end{bmatrix}_m = \begin{bmatrix} (\gamma_\infty - 1) \cdot \gamma_j \cdot R_j \cdot T_j \\ (\gamma_j - 1) \cdot \gamma_\infty \cdot R_\infty \cdot T_\infty \end{bmatrix}_c \tag{7}$$

In the above similarity relations, the most important parameter is the ratio of jet stream static pressure to free stream static pressure p_j/p_∞, which is called the "pressure drop ratio." In this experiment, the pressure ratio is regulated by the jet pressure regulating valve.

The free stream conditions γ_∞ and M_∞, and the geometric parameter A_j/A_∞ for the model can be chosen to correspond to the actual conditions without much difficulty.

Thus, the parameters to be considered include:

$$\gamma_j M_j^2,\ \gamma_j M_j^2 \beta_j^2,\ \gamma_j M_j^2 (RT)_j,\ \gamma_j M_j^2 (RT)_j^{-1},\ \gamma_j (\gamma_j - 1)^{-1} (RT)_j$$

which depend on the selected values of γ_j, M_j and $(RT)_j$.

In this experiment, the pressure drop ratio, the jet Mach number and the free-stream Mach number are simulated. The similarities in Mach numbers are achieved by controlling the following parameters:

a) the throat area of the Laval nozzle of the engine;
b) the distance between the Laval nozzle and the base of the engine;
c) the exit angle of the Laval nozzle.

According to the report NASA-TR-R-6, similarity conditions for temperature-dependent parameters γ_j and $(RT)_j$ can be ignored if the difference between the isentropic indices of air γ_∞ and the jet stream is less than 0.1. In this experiment, the isentropic index of air is 1.4, and the isentropic index of the jet stream is 1.33; hence the difference is $0.07 < 0.1$. Consequently, we believe that it is adequate to use a cold jet instead of a hot jet under these experimental conditions.

3. Model Selection

During the powered flight of a missile, due to the interaction between the free air stream and the tail jet streams of the ramjet engines, a region of separation of air/gas mixture is formed behind the missile body. This flow region has a significant effect on the missile performance.

In the absence of jet streams, the free stream at infinity will produce expansion waves of increasing strength when it reaches the base of the engine. When jet streams are present, interaction between the free stream and jet streams will produce a compression wave at the jet exit; behind the compression wave the pressure rises and the velocity decreases. If this compression wave can be attached to the afterbody of the missile, then the pressure at the tail section and base section of the missile will increase, thus reducing the tail drag and base drag of the afterbody. Furthermore, this effect should be enhanced by the Mach cones of the two side-mounted engines.

According to the report NASA-TR-R-6, experimental and theoretical research of axially-symmetric free jets have shown that the shock angle at the base of the engine can be obtained from the parameters M_∞, p_j/p_∞, M_j, γ_j as follows: $M_\infty = 2.0$, $\theta_j = 46°$, $M_\infty = 1.8$, $\theta_j = 44°$.

From this data we can calculate the length of the afterbody that would be reachable by the shock wave, and then determine the parameters of the model II afterbody by taking into consideration structural feasibility of the design.

In order to illustrate the adverse effect or large tail angle due to flow separation, we also designed two other afterbodies, model III and model IV. The four configurations are shown in Figure 1.

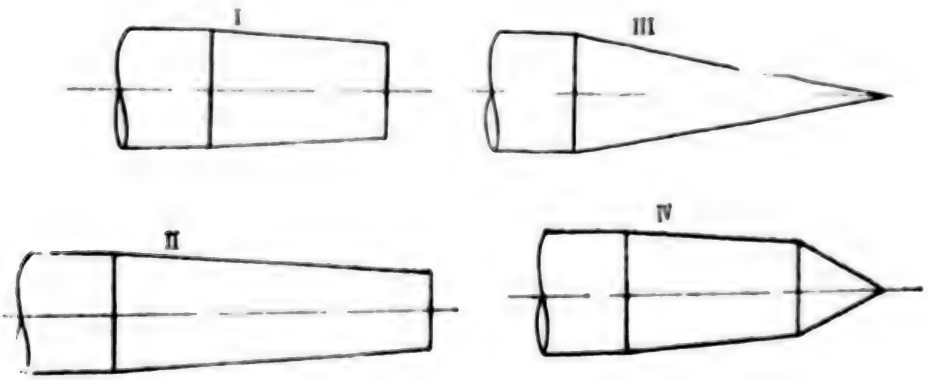

Figure 1. The Configurations of Four Different Afterbodies

The scale of the model is chosen to be 1:13 to that of the real missile. The model is placed at the first window on the right side of the wind tunnel; the attitude angle is $\gamma = -90°$. The main body of the model is connected to the advanced inner balance through the cone sleeve; the back side of the 6-division balance is connected to the air-vent support frame with $\bar{c} = 5$ percent and 45° back sweep through a stress connector. The swept-back support frame itself is a jet duct, and is connected to the pressure stabilizing chamber and the two simulated ramjet engines to form a complete jet system.

4. Experimental Results

The results of the jet experiment conducted in the FL-21 wind tunnel are presented in this section. Specifically, in the absence of the vertical tail, the base drag and tail drag of the four different afterbodies with and without jet streams are shown in Table 1.

Variations of the drag coefficients with M_∞ are presented in Figure 2.

Table 1. M = 2

	C_x without jet	C_x with jet	C_{xD} without jet	C_{xD} with jet
I	0.322	0.326	0.0945	0.0925
II	0.304	0.265	0.0448	0.0365
III	0.322	0.294	0	0
IV	0.335	0.346	0	0

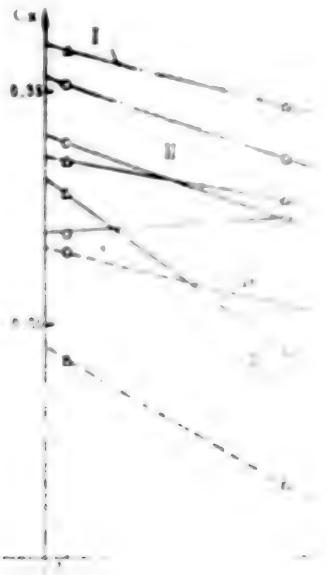

Figure 2. Variations of Drag Coefficients With Mach Number for Four Different Afterbodies

Δ--with jet o--without jet

I--original afterbody; II--extended afterbody; III--addition of a full cone; IV--addition of a small cone

It is seen that the presence of jet streams reduces the base drag of the model I afterbody but raises its tail drag; on the other hand, both the base drag and the tail drag of model II are reduced by the jet streams. A comparison of model I and model II results shows that the model II afterbody is

clearly superior in terms of drag reduction. At M = 2.0, the difference between the drag coefficients without jet streams is 0.018; with jet streams, the difference is 0.061. This is equivalent to a drag force of 400 kg, which corresponds to 30 percent of the missile body zero drag and 13 percent of the overall zero drag.

In the case of the model II afterbody with jet stream, we believe that the drastic reduction in drag is due to the high pressure created behind the shock wave. Because of the long afterbody of model II, the exit shock of the engine tail nozzle can reach the base section of the missile, causing the pressure to rise; consequently, it is more effective in reducing the base drag than the model I afterbody. In the case of the model I afterbody, the reduction in base drag is due to the interference effects of the shock wave on the tail jet, which cause the pressure to rise.

Generally speaking, in the absence of jet streams, the streamlines turn sharply at the end of the afterbody; the base region is essentially a stagnation zone, hence drag is very high. If there is a small jet stream, the drag will decrease; when the jet velocity V_j is equal to the free stream velocity V_∞, the drag coefficient of the afterbody is no longer affected by the jet stream or the stagnation zone. The model IV afterbody suffers large tail drag because of severe flow separation caused by the large tail angle. By comparison, the model III afterbody has smaller drag. Therefore, in designing the supersonic afterbody of a missile, careful consideration must be given to the selection of the tail angle.

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GENERALIZED VARIATIONAL PRINCIPLES FOR 2-DIMENSIONAL UNSTEADY TRANSONIC FLOW OVER OSCILLATING AIRFOILS

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[Text] Notations:

A_1, A_2, A_3, A_4	boundaries of the domain of solution (Figure 1)
A_0^T	domain of solution in R^2 at t = 0 and T
A_f, A_s	denote the surface of free trailing vortex sheet and the shock wave surface respectively
g, g_f, g_w	denote the (normal) velocities of the shock wave surface, the surface of free trailing vortex sheet and the wing surface respectively
i, i*	denote the enthalpy and stagnation enthalpy respectively $i^* = p/\rho + \frac{k-1}{2} A^2$
$\vec{i}$, $\vec{j}$, $\vec{k}$	unit vectors along the x,y,t directions in R^3
k	isentropic index
$\vec{n}$, $\vec{n}'$	unit vectors normal to the curved surfaces in R^2 and R^3
p	pressure
q, Q^j	denote the density flow q = ρA and arbitrary function $Q^j = Q^j(x,y,t)$, (j = 1-N)
R^2, R^3	denote the 2-dimensional space xy and 3-dimensional space xyt respectively
$\vec{s}$	displacement vector
t, T	denote time and the period of oscillation respectively
V, ∂V	denote the volume and the boundary surface area of the domain of solution in R^3
x, y	rectangular coordinates

$\vec{A}$	flow velocity vector $\vec{A} = A_1\vec{i} + A_2\vec{j}$
ρ	density
Φ	velocity potential
δ	fixed-domain variation

Superscript

0	constrained variation
'	parameters in R^3
T	matrix transposition

Subscript

pr	apriori parameters
∞	flow parameters at $x = \infty$
-, +	denote the left and right sides of the surface of discontinuity respectively
n, n'	denote the normal components in R^2 and R^3 respectively

I. Introduction

The study of unsteady transonic flow plays an important role in predicting the aeroelastic response, flutter characteristics and inlet distortion effects of wing surfaces and turbine blades. It is a complex and difficult problem not only because of its high degree of non-linearity but also because of the presence of unknown oscillating surfaces of discontinuity (e.g., the shock wave surface A_s and the surface of free trailing vortices A_f). Therefore, generally solution of the problem is obtained under various simplifying assumptions (e.g., small perturbations, low frequencies, simple harmonic motions, etc.) which limits the accuracy and the range of validity of the results. In this article, a new approach based on the variational principles for unsteady transonic flow is proposed which avoids the above-mentioned simplifying assumptions. This approach makes use of the "variable-domain" technique and the "natural boundary conditions" to facilitate numerical solution of the problem. The variational principle proposed in Ref. [4] will be re-derived as a member of the family of variational principles discussed in this article; in addition, a generalized form of the variational principles will be constructed using the method of linear combination[12,13].

II. Aerodynamic Equations for 2-Dimensional Unsteady Transonic Flow

In the study of 2-dimensional transonic flow, it is customary to assume that only weak shock waves are present, so that the problem is governed by the following dimensionless velocity potential equations[4,6]:

Equation of continuity:

$$\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{A}) = 0 \tag{1}$$

Equation of irrotationality:

$$\nabla \Phi = \vec{A} \tag{2}$$

Cauchy integral:

$$(k-1)\left(\frac{\partial \Phi}{\partial t} + \frac{A^2}{2}\right) + \frac{p}{\rho} = 1 \tag{3}$$

Isentropic condition:

$$p = \rho^k \tag{4}$$

The boundary conditions can be written as follows[4] (see Figure 1):

$$\left.\begin{array}{ll} \text{along } A_1 & \rho A_n = (\rho_\infty A_\infty)_{pr} \\ \text{along } A_2 & \rho A_n = (\rho_\infty A_\infty)_{pr} - (\rho_\infty / A_\infty)_{pr} \dfrac{\partial \Phi}{\partial t} \\ \text{along } A_3 & A_n = 0 \\ \text{along } A_4 & \rho(A_n - g_w) = (q_n)_{pr} \\ \text{along } A_f & p_- = p_+, \quad A_n = g_f \end{array}\right\} \tag{5}$$

where g_w and g_f denote the normal velocities of the wing surface A_4 and the surface of trailing vortex sheets A_f respectively; $(q_n)_{pr}$ denotes the blowing (suction) density flow distribution used for boundary layer control.

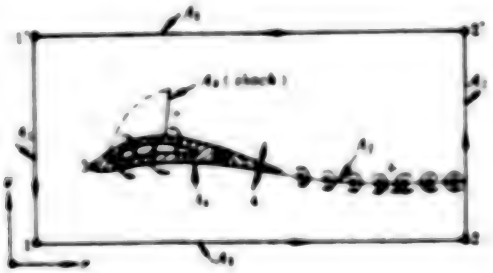

Figure 1. Unsteady Flow Over an Oscillating Airfoil

Along A_s, the following Rankine-Hugoniot shock wave condition holds[6,9]:

$$\left.\begin{array}{l} [\,p\,]\,/k + \rho(A_n - g)\,[\,A_n\,] = 0 \\ [\,\rho(A_n - g)\,] = 0 \end{array}\right\} \tag{6}$$

$$[\,A_\tau\,] = 0 \tag{7}$$

$$[\,i^*\,] = (k-1)g\,[\,V_n\,] \tag{8}$$

where $[X] = X_+ - X_-$ is the step increase of any flow parameter across the surface A_S.

On A_o^T (i.e., on the flow field at the instants t = 0 and t = T), if the airfoil is in oscillating motion with period T, then X should satisfy the following condition[4]:

$$X(x, y, t \pm jT) = X(x, y, t), \quad (j = 0, 1, 2, \cdots); \tag{9}$$

$$(\Phi)_{t=0} = (\Phi)_{t=T} \tag{10}$$

In addition, the Kutta condition requires that the static pressures at the pressure surface p and the suction surface s of the trailing edge 4 are equal[1]:

$$(p_+)_4 = (p_-)_4 \tag{11}$$

In the actual solution process, one would first choose a rear stationary point, then make successive corrections according to equation (11).

III. A Family of Generalized Variational Principles

1. Generalized Variational Principle I

The solution of the unsteady transonic flow problem yields a stationary value for the following functional J_1, i.e., $\delta J_1 = 0$, where Φ, Λ_x, Λ_y, p, ρ, A_f and A_S are all subject to independent variation.

$$J_1(\Phi, \vec{\Lambda}, p, \rho, A_f, A_S) = \iiint_{(\Omega)} \left\{ -\rho\left(\Lambda_x \frac{\partial \Phi}{\partial x} + \Lambda_y \frac{\partial \Phi}{\partial y} + \frac{\partial \Phi}{\partial t}\right) + \right.$$

$$\left. + \frac{1}{2}\rho \Lambda^2 - \prod \right\} dx\, dy\, dt + L \tag{12}$$

where

$$\prod(p, \rho) = \frac{1}{k-1}\left\{\frac{p}{k}\left[1 - \ln(p/\rho^k)\right] - \rho\right\}$$

$$L = -\iint_{(A_1)} (\rho_- \Lambda_-)_n \cdot \Phi \cdot dA + \iint_{(A_0)} (\rho_- \Lambda_-)_n \left[1 - \left(\Lambda_-\right)_n^{-1}\left(\frac{\partial \Phi}{\partial t}\right)\right] \Phi \cdot dA +$$

$$+ \iint_{(A_4)} \left(\frac{q_n}{\sqrt{1+q_n^2}}\right) \Phi \cdot dA$$

and $\dot{\Phi}$ is the "constrained variation" of Φ[11].

[Proof]: To determine the variation of the above equation, one must use the variable-domain variation formula. Let the functional be of the form:

$$I(Q) = \iiint_{(\Omega)} F\left(Q, \frac{\partial Q}{\partial x}, \frac{\partial Q}{\partial y}, \frac{\partial Q}{\partial t}\right) d\Omega \tag{13}$$

where $Q=(Q^1, Q^2, \cdots, Q^5)^T$

$$\frac{\partial Q}{\partial \zeta}=\left\{\frac{\partial Q^1}{\partial \zeta}, \frac{\partial Q^2}{\partial \zeta}, \cdots, \frac{\partial Q^5}{\partial \zeta}\right\}^T, \zeta=x, y, t$$

$$dV=dx\cdot dy\cdot dt$$

then if δs_n^* is the normal variation of the boundary of region V, the variation of equation (13) should be calculated from the following general formula[7]:

$$\delta I=\iiint_V \sum_{i=1}^{5}\left[\left(\frac{\partial F}{\partial Q^i}-\nabla\cdot G^i\right)\delta Q^i\right]dV+$$

$$+\oint_S \sum_{i=1}^{5}\left\{G_n^i\cdot\delta Q^i+\left(F-G_n^i\cdot\frac{\partial Q^i}{\partial n^*}\right)\delta s_n^*\right\}dA \qquad (14)$$

where the parameters (or operators) in 3-dimensional space R^3 are indicated by the superscript '*'; the parameters without the superscript are those belonging to the 2-dimensional space R^2.

By using equation (14) to carry out the volume integral in equation (12), we obtain:

$$F=\frac{1}{2}\rho A^2-\rho\left(A_0\frac{\partial\Phi}{\partial x}+A_1\frac{\partial\Phi}{\partial y}+\frac{\partial\Phi}{\partial t}\right)+H \qquad (15A)$$

$$Q=(\Phi, A_0, A_1, \rho, \rho)^T$$

$$G^1=\frac{\partial F}{\partial Q_0}i+\frac{\partial F}{\partial Q_1}j+\frac{\partial F}{\partial Q_2}k,$$

$$\left.\begin{aligned} G^2&=\frac{\partial F}{\partial \Phi_0}i+\frac{\partial F}{\partial \Phi_1}j+\frac{\partial F}{\partial \Phi_2}k=\rho(Aj+Bk)\\ G^j&=0,\ (j=3-5)\end{aligned}\right\} \qquad (15B)$$

where

$$Q_0=\frac{\partial Q}{\partial x},\quad Q_1=\frac{\partial Q}{\partial y},\quad Q_2=\frac{\partial Q}{\partial t}$$

Clearly, since

$$\nabla f=|\nabla f|\hat{n}=\nabla f\left|\frac{\partial f}{\partial t}\right|k$$

we have:

$$G_n^i=G^i\cdot\hat{n}=\rho(Aj+Bk)\cdot\nabla f/|\nabla f|=\rho\frac{|\nabla f|}{|\nabla f|}\left(A_1+\frac{\partial f}{\partial t}/|\nabla f|\right) \qquad (16)$$

Now consider a stationary curved surface S in R^3 space whose equation is given by

$$f(x, y, t)=0$$

In R^2 space, this represents a curve in motion whose velocity g is[4]:

$$g = \frac{dS_0}{dt} = -\frac{\partial f}{\partial t} \Big/ |\nabla f| \tag{17}$$

Also, we have:

$$|\nabla f| \cdot |\nabla f| \cdot \cos^2\theta = \left| \frac{|\nabla f|^2 + \left(\frac{\partial f}{\partial t}\right)^2}{|\nabla f|^2} \right| = 1 + g^2 \tag{18}$$

By substituting equations (17), (18) into equation (16), we get:

$$G_n = -\frac{\rho}{\sqrt{1+g^2}}(g - A_n) \tag{19}$$

Similarly, one can derive:

$$\frac{\partial \Phi}{\partial \tau} = \nabla\Phi \cdot \vec{s} = \nabla\Phi \cdot \frac{\nabla f}{|\nabla f|} = \frac{|\nabla f|}{|\nabla f|}\left(A_n - g\frac{\partial \Phi}{\partial n}\right)$$

$$= \left(A_n - g\frac{\partial \Phi}{\partial n}\right) \Big/ \sqrt{1+g^2} \tag{20}$$

Thus, we obtain the following:

$$\left.\begin{aligned} \sum_{i=1}^{3} G_i \cdot \frac{\partial U_i}{\partial \tau} &= G_i \cdot \frac{\partial \Phi}{\partial \tau} = \frac{\rho}{1+g^2}(g - A_n)\left(A_n - g\frac{\partial \Phi}{\partial n}\right) \\ \text{and} \quad -\sum_{i=1}^{3} \nabla \cdot G_i &= -\nabla \cdot G = \frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{A}) \end{aligned}\right\} \tag{21}$$

By substituting equations (15), (19)-(21) into equations (14), then making use of equation (12), and noting that the normal velocity of the wing surface S_W is known (because the translational and torsional vibrations of the wing are given), one can derive an expression for the variable-domain variation of equation (12):

$$\begin{aligned} \delta J = -\iiint_{\Omega} \Big\{ \Big[\frac{\partial \rho}{\partial t} + \nabla \cdot (\rho \vec{A}) \Big] \delta \Phi - \Big(\frac{\partial \Phi}{\partial x} A_x + \frac{\partial \Phi}{\partial y} A_y + \frac{\partial \Phi}{\partial t} - \frac{A^2}{2} + \frac{\partial I}{\partial \rho} \Big) \delta \rho + \\ + \Big(A_x - \frac{\partial \Phi}{\partial x} \Big) \rho \cdot \delta A_x + \Big(A_y - \frac{\partial \Phi}{\partial y} \Big) \rho \cdot \delta A_y - \frac{\partial I}{\partial \rho} \cdot \delta \rho \Big\} d\Omega - \\ - \iint_{S_1} (q_n)_0 - q_0) \delta \Phi \cdot dA + \iint_{S_2} \Big\{ (q_n)_0 \Big[1 - \frac{\partial \Phi}{\partial t} \Big/ (A_n)_0 \Big] - q_0 \Big\} \delta \Phi \cdot dA - \\ - \iint_{S_3} q_0 \cdot \delta \Phi \cdot dA + \iint_{S_4} [(q_0)_0 - \rho(A_n - g_0)] \frac{\delta \Phi}{\sqrt{1+g_0^2}} dA - \\ - \iint_{S_5 + S_6} \Big\{ (G_i \cdot \delta \Phi)_1 - (G_i \cdot \delta \Phi)_2 + \Big[\Big(F - G_i \frac{\partial \Phi}{\partial n} \Big)_1 - \\ - \Big(F - G_i \frac{\partial \Phi}{\partial n} \Big)_2 \Big] \delta x_0 \Big\} dA + \iint_{(S_1')} [(\rho)_{\infty_1} - (\rho)_{\infty_2}] (\delta \Phi)_{\infty} \cdot dA_{\infty} \end{aligned}$$

Thus, from $\delta J_1 = 0$ one can derive a set of stationary conditions for the functional J_1 as follows:

Euler equations: equations (1), (2), (3), (4) (total 5 equations)

Natural boundary conditions:

Along A_1: $\qquad \phi = (\phi)_0$

Along A_2: $\qquad \phi = (\phi)_0 - (\partial\phi/\partial t)\,\delta t$

Along A_3: $\qquad \delta\phi = 0$

Along A_4: $\qquad \rho(\phi - \phi_\infty) = (\rho)_0$

Along A_5: by invoking the essential condition $(\delta\phi)_1 = -(\delta\phi)_2$ and the Weierstrass-Erdman condition (or simply the W-E condition), one can derive the natural boundary condition as follows:

$$\phi = \phi_\infty \quad \text{and} \quad \rho = \rho_\infty$$

This is precisely the boundary condition at the oscillating free surface of trailing vortices (see the end of equation (3)). The condition $f_B = 0$ (it can be rewritten as $Df/Dt = 0$ by virtue of equation (17)) clearly indicates that the normal flow velocity at the surface of trailing vortex sheet is equal to the velocity of its own forward motion; in other words, there can never be any flow through the trailing vortex sheet.

Along A_6: by invoking the essential conditions $\phi = \phi_2$ and $(\delta\phi)_1 = -(\delta\phi)_2$, and the W-E condition, one can derive the natural surface conditions:

$$[\rho(\phi - \phi_\infty)]_2 = 0, \quad \text{(law of conservation of mass)} \tag{22A}$$

$$[p]_2 + \frac{\rho(\phi - \phi_\infty)}{1+\tilde{q}^2}\left[\phi - \phi_\infty - \frac{\partial\phi}{\partial t}\right]_2 = 0$$

The last equation can be rewritten as[4]:

$$[p]_2 + \rho(\phi - \phi_\infty)[\phi]_2 = 0 \quad \text{(normal momentum equation)} \tag{22B}$$

Taking the derivative of the essential condition $\phi_1 = \phi_2$ along the arc length tangent to the above wave line τ in R^2, one obtains:

$$\left(\frac{\partial\phi}{\partial\tau}\right)_1 = \left(\frac{\partial\phi}{\partial\tau}\right)_2,$$

i.e.,

$$[\phi]_2 = 0 \quad \text{(tangential momentum equation)} \tag{22C}$$

In addition, from the Euler's equation (3), one can write:

$$[s^{\bullet}] = -(1-k)\left[\frac{\partial \Phi}{\partial t}\right]$$

or it can be rewritten as

$$[s^{\bullet}] = (k-1)g[s_x] \tag{22D}$$

Clearly, equations (22A)-(22D) are precisely the Rankine-Hugoniot conditions (6)-(8) on the oscillating shock wave surface.

Two different methods of treatment can be used on A_0^T:

(1) By using the periodic condition (10) as the essential condition, one can obtain the natural (periodic) condition as follows:

$$(\rho)_{x=1} = (\rho)_{x=T} \tag{23}$$

Furthermore, from equations (10) and (2) we know that the flow fields at $t = 0$ and $t = T$ are identical; thus the following natural conditions can be derived from equations (23), (4) and (3):

$$(X)_{x=0} = (X)_{x=T} \tag{24}$$

Here, X denotes $\hat{s}$, p, or $\partial\Phi/\partial t$. In using the method of finite elements to find the solution, one can use the method of matrix reconstruction of Ref. [8] for numerical processing of the essential condition (10).

(2) The periodic condition (10) can also be converted to a natural surface condition by modifying the functional J_1, i.e., by adding the following boundary integral term:

$$\iint_{(\sigma)} [(\Phi)_{x=T} - (\Phi)_{x=0}](\rho)_{x=0}\, dA_{x=0} \tag{25}$$

Then, the natural (periodic) conditions on A_0^T can be derived from $\delta J_1 = 0$ as follows:

$$(\Phi)_{x=0} = (\Phi)_{x=T} \quad \text{and} \quad (\rho)_{x=0} = (\rho)_{x=T}$$

Using a similar method as in (1), one can deduce the necessary natural condition (24).

Therefore, we have shown that a complete solution of this problem can be obtained by using the generalized variational principles, including the matching conditions along the unknown oscillating surfaces of discontinuity.

A family of subgeneralized variational principles can be derived by using the method of recursive transform of Ref. [6]. However, we shall not discuss this technique in detail; only two of the principles are given below.

Subgeneralized variational principle II: $\delta J_{II} = 0$

$$J_{II}(\Phi, \vec{\Lambda}, A_f, A_s) = -\iiint_{(V)} \left[1-(k-1)\left(\frac{\partial \Phi}{\partial t}+\frac{\Lambda^2}{2}\right)\right]^{\frac{1}{k-1}} \left\{\Lambda_x \frac{\partial \Phi}{\partial x}+\Lambda_y \frac{\partial \Phi}{\partial y}+\right.$$
$$\left.+\left(\frac{k-1}{k}\right)\frac{\partial \Phi}{\partial t}-\frac{1}{k}\left(1+\frac{k+1}{2}\Lambda^2\right)\right\} dx\cdot dy\cdot dt + L \qquad (26)$$

where Φ, $\vec{\Lambda}$, A_f and A_s are subject to independent variation with equations (3) and (4) as constraints.

By using a similar approach as for J_I, it can be shown that from $\delta J_{II} = 0$ one can derive the Euler's equations (1) and (2) and a set of natural boundary conditions identical to those of J_I.

Variational principle III: $\delta J_{III} = 0$

$$J_{III}(\Phi, A_f, A_s) = \iiint_{(V)} \frac{p}{k}\, dx\cdot dy\cdot dt + L \qquad (27)$$

where Φ, A_f and A_s are subject to independent variation with equations (2), (3), (4) as constraints.

By using a similar approach as for J_I it can be shown that from $\delta J_{III} = 0$ one can derive the Euler's equation (1) and a set of natural boundary conditions identical to those of J_I. It is noted that the variational principle III is the variational principle proposed in Ref. [4].

IV. Further Generalization of the Generalized Variational Principles

By using the method of linear combination proposed in Ref. [12,13], one can easily construct more general forms of the generalized variational principles which contain a number of arbitrary parameters k_i ($i = 1,2,\ldots$). Here, we shall construct a more general two-parameter family of functionals J_G based on J_I, J_{II}, and J_{III}:

$$J_G(\Phi, \vec{\Lambda}, p, \rho, A_f, A_s, k_1, k_2) = k_1 J_I + k_2 J_{II} + \left(1-\sum_{i=1}^{2} k_i\right) J_{III} =$$

$$= \iiint_{(V)} \left\{ k_1\left(\frac{\rho\Lambda^2}{2}-\Pi\right)+\frac{k_2}{k}\left(1+\frac{k+1}{2}\Lambda^2+\frac{\partial \Phi}{\partial t}\right)\left[1-(k-1)\left(\frac{\partial \Phi}{\partial t}+\frac{\Lambda^2}{2}\right)\right]^{\frac{1}{k-1}} - \right.$$
$$\left. - \left\{ k_1 \rho + k_2\left[1-(k-1)\left(\frac{\partial \Phi}{\partial t}+\frac{\Lambda^2}{2}\right)\right]^{\frac{1}{k-1}}\right\}\left(\Lambda_x \frac{\partial \Phi}{\partial x}+\Lambda_y \frac{\partial \Phi}{\partial y}\right)+\right.$$

$$+\frac{1-\sum_{i=1}^{n} k_i}{k}\left[1-(k-1)\left(\frac{\partial \Phi}{\partial t}+\frac{\left(\frac{\partial \Phi}{\partial x}\right)^2+\left(\frac{\partial \Phi}{\partial y}\right)^2}{2}\right)\right]^{\frac{k}{k-1}}\Bigg\} dx\cdot dy\cdot dt+L \qquad (28)$$

It is not difficult to show that the Euler's equations and natural conditions derived from $\delta J_G = 0$ are identical to those for J_I.

V. Concluding Remarks

As an extension of Ref. [4], this paper establishes a generalized variational principle and its derived family of principles for this problem. The main objective is to provide a sound theoretical basis for the numerical methods (primarily the finite element method), and to provide a new approach for calculating the geometric characteristics (particularly the oscillation process) of various unknown surfaces of discontinuity (shock waves, free trailing vortex sheets). This paper also takes into account the suction and/or blowing effects along the wing surface.

The theory presented in this paper can be extended to the case of 3-dimensional wing surface, and 2-dimensional and 3-dimensional turbine blades.

3012/6091
CSO: 4008/30

STUDY ON CHROMOSOME ABERRATIONS IN NUCLEAR WORKERS

Shanghai HE JISHU [NUCLEAR TECHNIQUES] in Chinese No 10, Oct 86 pp 57, 58

[Article by Zhu Bingcha [2612 3632 6865], of the Naval Medical Research Institute, and Liu Baoyi [0491 0202 5030] of Naval Hospital 409]

[Text] We have studied chromosome aberrations in peripheral blood lymphocytes in maintenance workers in nuclear reactors both before and after their maintenance work routines. The following is a report on the findings.

I. Materials and Method

1. Subject: There Are Three Groups of Subjects:

(1) Maintenance worker group: there are a total of 24 maintenance workers in this group, all of whom are young adult males, ages between 22-31, and all of whom work in radioactivity-related maintenance work.

(2) Non-maintenance worker group: there are a total of 30 young adult males, ages between 20-30, none of whom has participated in radioactivity-related maintenance work.

(3) Normal group: there are 24 subjects in this group, all of whom are young adult males, ages between 18-30, and all of whom are healthy workers not employed in nuclear reactors.

2. Radioactive dosage: through thermoluminescent dosemetric analysis using calcium sulphate film badges worn by the subjects, the range of ambient radioactivity during 6 months of the maintenance period was determined to be between 83-303 mR, and the average accumulated personal dosage was 133.5 mR. Through the use of urine analysis of the 60 Co, 59 Fe, 239 Pu isotopes, and through a thyroid analysis of the 131 I isotope, no internal radioactive pollution was detected.

3. Chromosome aberration analysis: through the use of whole-blood micro-analysis, and improvements on the analysis of peripheral blood cultures according to Moorhead (Footnote 1), and in accordance with the method and standards of WHO (Footnote 2), a microscopic analysis of 200 metaphase cells per subject was conducted and the various chromosome aberrations represented in percentages were tabulated.

II. Results

The peripheral lymphocyte chromosome aberrations of the various groups are analyzed and the results shown in Table 1. The results show that the difference between the normal group and the non-maintenance groups does not reach statistical significance. On the other hand, the percentage of acentric fragments in the maintenance group is significantly higher than the normal group and the non-maintenance groups does not reach statistical significance. On the other hand, the percentage of acentric fragments in the maintenance group is significantly higher than the normal group and the non-maintenance group ($P < 0.05$), and there are also two dicentric chromosomes in one cell scored by one of the researchers. In comparing the rate of acentric-fragment aberrations of 18 workers before and after maintenance work routines, the difference is likewise statistically significant ($P < 0.05$) as shown in Table 2.

Table 1. Peripheral Lymphocyte Chromosome Aberrations of the Various Groups

			Percentages of Chromosome Aberrations		
Group	No. of Subjects	No. of Cells Analyzed	Acentric Fragments	Dicentric Chromosomes	Group G Terminal Deletions
Maintenance	24	4,800	0.375	0.042	0.021
Non-maintenance	30	6,000	0.183	0	0
Normal	24	4,800	0.167	0	0

Table 2. Peripheral Lymphocyte Chromosome Aberrations of 18 Workers Before and After Maintenance Work Routines

		Percentages of Chromosome Aberrations		
Time	No. of Cells Analyzed	Acentric Fragments	Dicentric Chromosomes	Group G Terminal Deletions
Before Maintenance	3,600	0.139	0	0
After Maintenance	3,600	0.417	0.056	0.028

In order to analyze the relationship between the dosage of radiation and the amount of chromosome aberration, we divided maintenance workers into two groups according to dosage of radiation for analysis. The first group received >100mR of radiation, and the second group received <100mR of radiation. The results reveal that the former group shows an average of 0.4 percent acentric-gragment aberration, and the latter group shows an average of 0.25 percent, thus, failing to reach statistical significance.

III. Discussion

1. According to the observed data, the maximum dosage that nuclear reactor maintenance workers sustained is only 303mR, and no obvious internal radioactive pollution is evident. On the other hand, the peripheral blood lymphocyte acentric-fragment aberration rate of the workers is already markedly elevated. Therefore, lymphocyte chromosome aberration in the diagnosis of chronic radiation damage is a sensitive indicator in cases of the occupational accumulation of small amounts of radiation. If combined with other laboratory tests and medical symptoms, it will provide real assistance in the diagnosis of chronic radiation damage. However, because cell damage is small and chromosome aberrations are relatively minor with a small amount of accumulated radiation, it is necessary to analyze a large number of cells to obtain quantifiable results and reach desired statistical precision.

2. Some cells contain unstable aberrations. Due to structural malformation, these cells will die because of a disturbance while the cells are dividing, or lose fragments in mitotic division. Consequently, in the course of time, the rate of aberrations will show a gradual decline. Therefore, it is more accurate to run the tests as soon as the radiation phase is complete. It is observed (Footnote 3) that some stable aberrations usually do not affect cell division, and the rate of aberration will remain relatively constant. It is possible in future research to use stable aberrations in the diagnosis of chronic radiation damage to reflect more precisely the radiation sustained by the individual.

Special appreciation is due Supervisor Wang Yuexing [3769 2588 5281] for his review of this article.

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12996/12851
CSO: 4008/3005

ANTILEUKEMIC DRUG SUCCESSFULLY PRODUCED

Beijing RENMIN RIBAO in Chinese 26 Aug 86 p 1

[Article: "Anti-leukemia [illegible] Successfully Developed and Manufactured: The Drug Possesses Directed and Selective Power of Destruction Towards Cancerous Cells"]

[Text] Another "biological missile" with a directed and selective power of destruction towards cancerous cells has been produced by the laboratory of the Antibiotics Research Institute, the Chinese Academy of Medical Science.

This kind of "biological missile" is a compound medicine, a "monoclonal antibody medicine," produced out of the chemical combination of the "monoclonal" anti-leukemia antibody and the anti-cancer antibiotic "zhengguang." Its arrival comes after the successful manufacture of the compound medicine "monoclonal antibody drug," a "biological missile" that is effective in the fight against cancer of the liver, which was produced by the Shanghai Biological Research Institute of the Chinese Academy of Science, the No 2 Medical University of Shanghai, and others. It represents another important development in the field of medical bioengineering research in our country.

In-vitro experiments confirm that this "monoclonal antibody" compound medicine when compared to simple anti-cancer drugs is 12 times as effective. At the same time, using this new product enables the reduction of harmful sideeffects of anti-cancer drugs on normal cells. Results from animal experiments also show preliminary success in the cure of cancer. This product has opened up new avenues for medical applications in the destruction of cancerous cells and raised new hopes in the fight against cancer.

The use of the "monoclonal" antibody and anti-cancer drugs and antibiotics to treat cancer means the use of the "monoclonal" antibody as the "carrier" and the use of drugs and antibiotics as the "missile's warhead." The "biological missile" thus constituted has selective power of destruction over cancerous cells. The selectivity is a research question of considerable interest in recent years both in China and elsewhere in the world.

The cancer research unit of the Antibiotics Research Institute, Chinese Academy of Medical Science, is led by Zhen Yongsu [3914 3057 5685] and has for a long time investigated the selection of anti-cancer antibiotics and the

pharmacology of anti-cancer drugs. The institute successively manufactured for the medical application of anti-cancer [illegible] "guanghui," "zhengguang," "yingyang," and several others. Research on the "yingyang" antibiotic received the 1982 Second-honor National Invention Award. Since 1983, the Antibiotics Research Institute staff began research on the combination of the "monoclonal" antibody and anti-cancer drugs to improve the effects of treatment. In 1985, they joined forces with the Cancer Research Institute of the Academy of Medical Science and combined the anti-leukemia "monoclonal" antibody developed by Chen Yuxian [7115 3022 0103], a research assistant at the Cancer Research Institute, and the "zhengguang," antibiotic developed by the Antibiotics Research Institute to form the compound "monoclonal antibody medicine." It was tested for its biopotency in vitro and animal experiments were also successfully conducted.

Early this year, the Antibiotics Research Institute of the Academy of Medical Science, the Henatological Disorders Institute, and the Xiehe Hospital formed an interdisciplinary study group in preparation for the concerted effort in the research of the use of "biological missiles" to treat cancer during the Seventh "5-Year Period." The goal of the group was to establish several "missile carriers" with different "warheads" to combat leukemia, nasopharyngeal cancer, cancer of the liver, cancer of the villous gut, and teratoma. It was hoped that small-scale medical application could be attempted. At the present time, based on the experience in the selection of cancerous cultures from nasopharyngeal and liver cancer, the Antibiotics Research Institute has already separated "monoclonal" antibodies for treatment of nasophraygeal and liver cancer and is vigorously doing research in the combination of these two antibodies with anti-cancer drugs.

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ENZYMES FROM PINEAPPLE AND THEIR DRUG PRODUCTS

Guangzhou NANGANG RIBAO in Chinese 17 Oct 86 p 4

[Text] During the end of the last century, hydrolytic proteinous enzymes from pineapples were discovered in pineapple juice. However, because of technological limitations, large-scale manufacture and extraction of hydrolytic proteinous enzymes from pineapples had not been achieved. It was not until 1958 when a break-through was achieved in the United States, and drugs containing hydrolytic proteinous enzymes from pineapples became widely available. There are only very small number of countries that can manufacture this kind of medicine. During the late sixties, the Shanghai Biochemical Institute of the Chinese Academy of Science successfully researched the industrial production of hydrolytic proteinous enzymes from pineapples in Cuangxi. In 1971, the Qioguang pharmceutical company in Cuangzhou began production of pineapple enzymes tablets that are soluble in the intestines.

Pineapple enzymes are a kind of protein hydrolytic enzymes obtained from pineapple juice or juice from pineapple stems. After ingestion, some of the enzymes are absorbed in the form of polypeptides. These polypeptides can assist in the hydrolysis of fibro-proteins in the human body and remove the fibro-protein or blood clots caused by inflammation or injury. The end result is improved local circulation and increased blood vessel permeability. It is for these reasons that the enzymes are excellent in reducing inflammation.

In 1974, after repeated studies by the technical staff of the Qiaoguang Pharmaceutical company, pineapple enzymes and human bile were combined to produce combined pineapple enzyme tablets. Bile has been used since ancient times in China in the cure of whooping cough. After analysis, it was determined that the bile salts in bile can reduce or eliminate the pathological excitability of the central nervous system, and therefore results in the elimination of the convulsive contraction of the smooth muscles in the bronchi and results in the stoppage of coughing. The combined pineapple enzyme tablet has the following properties: remove phlegm, controls coughing, eliminates inflammation, reduces fever. The drugs are suitable for the cure of inflammatory diseases such as coughing with phlegm, whooping cough, the common cold, fever, acute and chronic bronchitis, asthma associated with bronchitis, emphysema with coughing and asthma, lymphangiitis, pharyngitis, and naso-sinusitis.

In 1985, Qiaoguang Pharmaceutical company combined pineapple enzymes with asparagus powder and produced emulsoid capsules. Asparagus powder contains asparagine, which can prevent health cells from becoming malignant, and the rate of cure of mammoplasia reaches 90.17 percent.

Other drug products include pineapple enzyme tablets and pineapple enzymes for children. Drug products produced using pineapple enzymes are non-toxic to the human body and cause no side-effects.

12996/12828
CSO: 4008/3009

OPIATE RECEPTOR SOLUBILIZATION, BINDING STUDIED

Beijing YAOXUE XUEBAO [ACTA PHARMACEUTICA SINICA] in Chinese Vol 20, No 10, 20 Oct 85 pp 721-725

[Article by Liu Yanxin [0491 1750 0207], Li Lingyuan [2621 7227 3293], and Jin Yinchang [6855 5593 2490], Institute of Basic Medical Sciences, Chinese Academy of Medical Sciences; paper received 9 January 1985; preliminary results were presented at the 1981 National Meeting of the Pharmacological Society; parts of this work were presented at the Ninth International Congress of Pharmacology, London, 1984 (IUPHAR Abstract 1407 p)]

[Text] Abstract: Chromatography on Sepharose 6B of a Triton x-100 extract of rat brain P_2 membrane homogenate, after incubation with tritium-labeled etorphine (^{3}H-etor) or tritium-labeled Quinine Biphenylhydroxylacetate ester (^{3}H-QNB), showed that the opiate receptor and the muscarinic receptor co-eluted from the column. They both have a molecular weight of about 450,000 daltons. Solubilization of the P_2 homogenate with CHAPS (3-[3-cholamidopropyl)-dimethylammonio]-1-propane-sulfonate) gave active opiate and muscarinic receptors. Dilution of the solution with the Tris buffer (50 mM, pH 7.5) resulted in a 25-fold increase of the binding capacity of opiate receptors. When CHAPS (1 mM) was present in the dilution buffer, no significant change in binding was observed.

Key words: Opiate receptor; Muscarinic receptor; receptor solubilization.

Since the presence of opiate receptors in the brain tissues was established in 1973, there has been substantial interest in studying the solubilization, purification, and characterization of the receptor. In the past decade, many laboratories abroad have reported[1-6] the use of various solubilizing agents to solubilize opiate receptor-ligand complex or active opiate receptors as well as the characterizations of the receptor.

CHAPS is a new ionic detergent, whose application in the solubilization of opiate receptor has not been reported in China. This article describes our study of the properties of the CHAPS-solubilized opiate receptors and the Triton x-100 solubilized opiate receptor-ligand complex.

Materials and Methods

1. Reagents. ^{3}H-etor (40 Ci/mmol) and etor were synthesized by the Department of Pharmacology of the Shanghai First Medical College. ^{3}H-QNB (17 Ci/mmol) was synthesized by the Academy of Military Medicine. QNB was synthesized by the Institute of Pharmaceutical Chemistry of the PLA.

2. P_2 Membrane Preparation, Its Binding With ^{3}H-labeled Ligands, and Solubilization. To the tube for non-specific binding was added ^{3}H-etor (6.5 nM) or ^{3}H-QNB (4 nM) and rat brain P_2 membrane preparation (abbrev. P_2 preparation). To the tubes for total binding, either etor (10 µM) or QNB (4 µM) was omitted. Tris buffer was added to all the tubes to make a final volume of 25 ml (containing 10-15 mg of protein). Cold Tris buffer (2.5 ml) was added after incubation at 30°C for 15 minutes. After centrifugation at 3,000 rpm for 10 minutes, the same amount of cold Tris buffer was added to the pellet and centrifuged again. The supernatant was discarded and 1.5 ml of a 1 percent Triton x-100 solution were added to the pellet, which was stirred at 4°C for 20 minutes and centrifuged at 100,000 grams for 1 hour (4°C). The protein concentration of the supernatant was determined by the Lowry method.[8] An aliquot of 0.2 ml was added to 10 ml of scintillation liquid and counted with a scintillation counter.

3. Solubilization of P_2 Membrane Receptors and Assay of Their Binding Activity. The literature method[6] was followed for solubilization. To the P_2 preparation (protein concentration 12 mg/ml) was added CHAPS (10 mM, final concentration), stirred at 4°C and centrifuged at 100,000 grams for 1 hour. To 0.6 ml of the supernatant was added ^{3}H-etor (3.1 nM) or ^{3}H-QNB (2 nM). To the tubes for non-specific binding, but not the tubes for total binding, was also added the non-labeled etor (5 µM) or QNB (2 µM). The volume was brought up to 1 ml with a Tris buffer. The tubes were incubated at 30°C for 15 minutes and saturated ammonium sulfate (1 ml) was added. The solution was filtered through 7101 fiberglass filter paper with suction after sitting on an ice bath for about 2 minutes. After washing with 50 percent ammonium sulfate, the filter membrane was placed in a counter cup, and 10 ml of scintillation liquid were added and counted.

Results

1. Solubilization of ^{3}H-etor- or ^{3}H-QNB-Receptor Complex

Triton x-100 was used to solubilize the complex of P_2 membrane preparation with ^{3}H-etor or ^{3}H-QNB. Protein recovery was 39±8.7 percent. The recovery of the labeled opiate receptor (67.6±16 percent) is higher than that of the labeled muscarinic receptor (36±1.4 percent).

The separation of the solubilized receptor-ligand complex by Sephadex G-200 column chromatography, which was monitored at 280 nm, showed two peaks. Peak I is smaller and shows specific radioactive binding whereas peak II is larger but not radioactive. When Triton x-100 was added to the solubilizing solution, the height of peak II increased, suggesting that it is a Triton peak.

Two radioactive peaks were obtained when the solubilized receptor-ligand complex was separated by Sepharose 6B chromatography. Peak I coincides with the protein peak detected by monitoring at 280 nm (Figure 1). After hydrolysis, it gave 10 amino acid spots on a two-dimensional chromatogram. Therefore, it is the opiate receptor peak. Peak II shows no absorption at 280 nm and contains no amino acid as determined by two-dimensional chromatography. Furthermore, when free ^{3}H-labeled ligands were added, the size of peak II increased drastically, suggesting that it is the unbound ^{3}H-labeled ligands. No receptor of either ligands was obtained when the cerebellar P_2 membrane preparation was treated with labeled compounds, solubilized, and chromatographed.

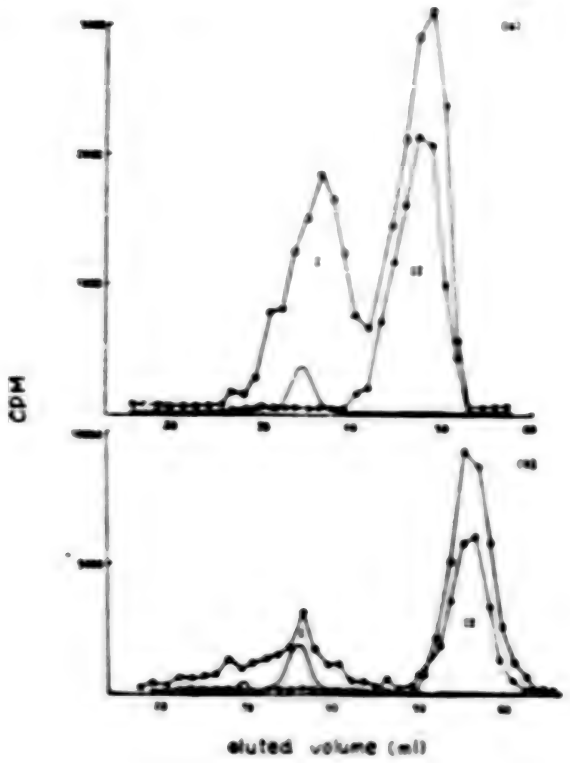

Fig 1 a. Elution profile on Sepharose 6B chromatography of Triton x-100 extract of P_1 bound with ^{3}H-etor P_1 membrane preparation (13.4 mg/ml) was incubated with ^{3}H-etor (6.5 nM), with (•——•) or without (○——○) unlabelled etor (10 μM), and solubilized with Triton-x 100 (1%). After centrifugation (100,000 g, 1 h, 4°C), 1 ml of the supernatant was placed on a Sepharose 6B column (1.5 × 90 cm) and eluted with cold 0.05 M Tris-buffer (pH 7.4, 50 mM). Protein concentration was monitored by Uvicord (280 nM) and determined by Lowry method. Peak I was found to be a protein peak and II was a ^{3}H-etor peak. b. Elution profile of P_1 bound with ^{3}H-QNB. The procedures was the same as above except that the ligand used was ^{3}H-QNB (4 nM) and unlabelled QNB (4 μM)

Fig 2. Paper chromatogram of radioactive peak I after acidolysis. Part of radioactive peak I was hydrolyzed by HCl (6.7 N) for 16 h. The hydrolysate was analyzed by 2 dimensional paper chromatography at room temperature. The first dimension was performed with n-butanol—formic acid—water (15 3:2), the second dimension with n-butanol—ammonium hydroxide (12%)—ethyl alcohol (95%) (13 3:3). Color was developed by 0.8% ninhydrin spray

The molecular weight of the opiate receptor was estimated to be 450,000 by gel filtration method (Figure 3). The muscarinic receptor has a similar molecular weight.

The specific binding activity of the opiate receptor was detected at R_f 0.18 after the solubilized opiate receptor-^{3}H-etor complex was separated by polyacrylamide gel electrophoresis (Figure 4).

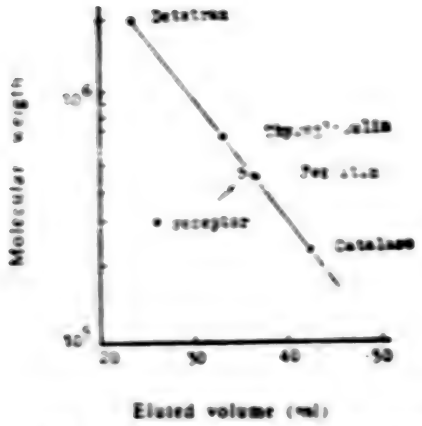

Fig 3. Estimation of molecular weight of solubilized ^{3}H-etor-bound complex on Sepharose 6 B. Sample (1 ml) was applied to a Sepharose 6 B column (1.5 × 30 cm) and elated with Tris buffer (50 mM, pH 7.4) at 4°C. Protein standards were monitored by absorbance at 280 nm, and the radiolabelled complexes were monitored by liquid scintillation spectrophotometry.
• Receptor, opiate receptor or muscarinic receptor

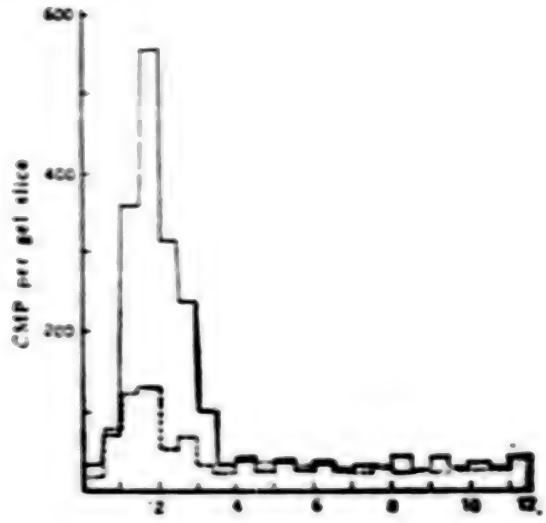

Fig 4. Electrophoretic analysis of the ^{3}H-etor-bound complex. Electrophoresis of the solubilized ^{3}H-etor-bound complex on 7.5% polyacrylamide cylindrical gel under nondenaturing conditions. Gels were prepared according to the procedure of Davies and Stark[6], and electrophoresis was carried out at 3 mA for 1.5 h. Radioactivity was monitored in 0.5 cm slices by liquid scintillation spectrophotometry. Total binding (——) and nonspecific binding (– – –)

2. Solubilization of Membrane Preparation

The P_2 preparation was solubilized with 10-mM CHAPS and collected by ultracentrifugation. The protein recovery is 32±2.5 percent. After combining the solubilized preparation with ^{3}H-etor or ^{3}H-QNB and separation by Sepharose 6B chromatography, peaks with specific binding activity were obtained, which coincide with the peaks showing protein activity (Figure 5). Recovery of activity are 22.8±7.1 percent and 11.4±2 percent, respectively, for the opiate receptor and muscarinic receptor.

3. Effect of Dilution

As shown in Figure 6, when the protein concentration of the liquid in the assay tubes is 1 mg, the specific binding activity is 0.037±0.029 pmol/mg

protein. When the liquid is diluted with Tris, which results in the dilution of protein concentration, there is an obvious increase in binding. With 10-fold dilution (i.e., when the protein concentration is 0.6 mg/ml), the specific binding is 0.9±0.1 pmol/mg protein, a 25-fold increase. With the presence of CHAPS in the dilution buffer (1 mM), no significant increase in binding can be seen.

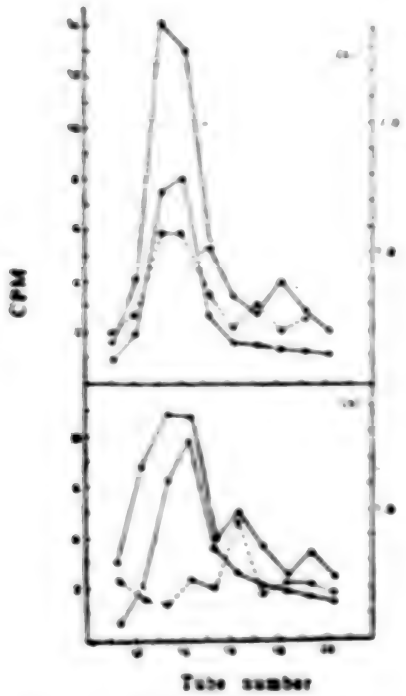

Fig 5. a. Elution profile of solubilized opiate receptor. P_3 fraction of rat brain was solubilized with CHAPS (10 mM) and centrifuged at 100,000 g for 1 h. The supernatant was incubated with 4.3 nM ^{3}H-etor with (•——•) or without (•——•) unlabelled etor (1 μM) and fractionated on Sephadex G-200 column. Protein content (•——•) was determined by Lowry method[9]. b. Elution profile of solubilized muscarinic receptor. The procedure was the same as above except that ^{3}H-QNB (4 nM) and unlabelled QNB (4 μM) were used instead of ^{3}H-etor and unlabelled etor.

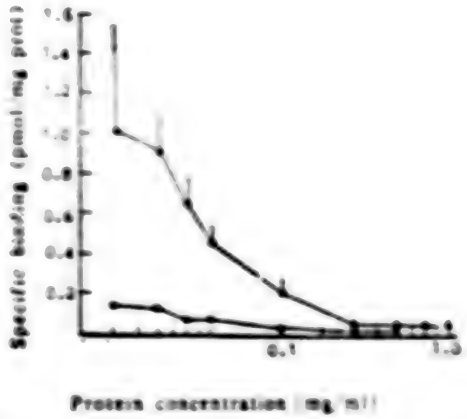

Fig 6. Effect of dilution on binding activity of opiate receptor in solubilized P_3 preparation. P_3 fraction of rat brain was solubilized with CHAPS (10 mM) and centrifuged under 100,000 g for 1 h. The supernatant was diluted with Tris-buffer (pH 7.4, 50 mM) (•——•) or Tris-buffer containing 1 mM CHAPS (•——•). Aliquots of the diluted supernatant were tested for specific binding activity with ^{3}H-etorphine (4.3 nM).

Discussion

Puget, et al.[3] used Sepharose 6B to isolate the ^{3}H-etor bound opiate receptors that were solubilized with bile salts. Two radioactive peaks, one high molecular weight (500,000) and the other low molecular weight (whose retention is the same as that of the free ^{3}H-etor), were obtained. The authors believed that the low molecular weight component was the opiate receptor or a fragment of the opiate receptor that was different from the high molecular

weight ones. We used Triton x-100 as a solubilizing detergent to get two elution peaks. Through the amino acid composition analysis of the two peaks, it is clear that peak I contains 10 kinds of amino acid residue and is the opiate receptor with binding activity. Peak II does not contain amino acid (see Results section). It is not a receptor protein peak. Because the retention of this peak is the same as that of the unbound ^{3}H-etor, we believe that the peak derives from the ^{3}H-etor breaking away from receptor-ligand complex during chromatography.

Simonds, et al.[6] suggested that the structure of the detergent is the key in the solubilization of opiate receptors and that the ideal detergent would contain at the same time oppositely charged ionic groups and a steroid nucleus. CHAPS happens to fit the description. When it is used for solubilization, one gets active receptors. With Triton x-100, no such active opiate receptors are obtained. This shows that CHAPS has less effect than Triton x-100 on the ligand binding site of the receptor.

The dilution experiment data show that the lowered concentration of detergent in the solubilized supernatant results in the raised binding activity of the receptor. Part of the reason may be that the detergent covers some binding sites and dilution can re-expose these binding sites just like the insulin receptors,[10] whose covered binding sites can be re-exposed by solubilization because of the disintegration of the phospholipid layer in the membrane structure.

Experimental data show that the solubilized P_2 membrane preparation also has the specific binding activity of the muscarinic receptor. Gel filtration fails to separate the two kinds of receptors. In the radioactive labeled binding experiments, high concentrations ($10^{-5} \sim 10^{-4}$ M) of etor and QNB display cross-inhibition. With WGA-Sepharose affinity chromatography, the two kinds of receptors also elute under one peak (unpublished result). This seems to suggest certain structural correlation between the two kinds of receptors. We are currently investigating this possibility.

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BLOOD DONATION MANAGEMENT ENFORCED

Beijing JIAN KANG BAO in Chinese 2 Nov 86 p 3

[Text] According to Xiao Xingfu, [5135 2502 3940] research associate at the Chinese Medical Science Blood Transfusion Research Center, blood donation--certainly a noble deed of saving the dying and helping the maimed. However, in recent years, as a result of the lack of knowledge in the commercialization of blood products, there exists situations described as 'the commerce of red gold' and 'blood transaction', resulting in inferior blood used in clinical transfusion. This in turn results in seriously jeopardizing the health of blood recipients and medical workers. This problem deserves our serious attention."

At the moment, blood products have reached 5 million liters in our nation, and are used widely in clinical applications. However, tests review that because of the inferior blood products, in 563 cases of blood recipients, post-transfusion hepatitis rate was at 15.99 percent. In another study, tests for B-hepatitis virus in 1,957 workers in various occupations as well as the population of blood donors show an alarming 19.5 percent positive reaction. The rate of occurence was highest in medical workers.

Why are inferior blood products used in clinical applications? One of the reasons is that some donors, in the pursuit of financial gain, lied about their clinical history, and resulted in the transmission of diseases transmissible through blood transfusion. It is noteworthy that current tests and analysis of the origin of pathogenesis are limited. For example, B-hepatitis virus is infactious in chimpanzees when diluted 10 million times. On the other hand, current analysis is unable to detect the virus at that dilution. Another reason is the inability of current procedures to test for non-A and non-B types of hepatitis viruses. Other reasons include situations where unsuitable donors hungry for payment would donate under falsified names, addresses, and even ask suitable donors to provide satisfactory test results so that they may donate their unsuitable blood. Some donors do not observe the time required between transfusions and donate blood too frequently, and donate blood to different blood centers. These are all very serious problems.

How do we guarantee blood that meets the required standards for clinical applications? Xiao Xingfu suggests that different levels of health care departments establish appropriate leadership and administrative infrastructure in blood donation centers. At the same time, it is imperative to have centralized control and organization of blood donors. Furthermore, laws and regulations should be enacted in regard to blood donation, and standards should be established for blood donation.

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MEASUREMENT OF TRANS-OXIDE ENZYMES STUDIED

Beijing JIAN KANG BAO in Chinese 2 Nov 86 p 4

[Text] A drop of blood from a finger, a few pieces of economical equipment, and 30 minutes will provide a test for the amount of trans-oxide enzymes in the human body. This method has been studied recently.

The determination of trans-oxide enzymes is a fairly useful indicator in the research on human aging, cancer, blood, and immunology. Trans-oxide enzymes exist widely in human beings and organs of many living things. They are the major enzymes that defend and prevent the destructive forces of auto-enzymes. Auto-enzymes are intermediate products inside the human body that have not been completely oxidized. They can destroy human cells, and cause human aging, and will also activate cancerous material, and cause cancer. Other conditions caused by auto-enzymes include inflammation and auto-immunological diseases. Trans-oxide enzymes prevent aging and diseases by dissolving and annihilating the effects of auto-enzymes. Therefore to determine the level of trans-oxide enzymes in the human body seems to be a very important task.

There are many methods currently used for the determination of trans-oxides, and involve the research efforts both in China and overseas. Existing methods all require about 5 ml of venous blood sample from patients. These methods are not suitable for older people and patients whose veins do not allow easy blood sampling. Also, the procedures are quite involved, the reagents are expensive, and the time required for testing is long. If blood obtained from an ear is used, the tests may not be reliable and accurate. On the other hand, there is a new procedure researched by the Naval Engineering Academy's 28 year-old technician Ding Kexiang and others. The test using blood from a finger uses only one-thirtieth of the blood used in existing methods. In batch tests the time saved is seven to eight times that of the existing tests. This procedure should be promoted and used in basic health care units. In evaluation meetings, authorities generally agree that this procedure is a break-through and has reached advanced levels in the nation.

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